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LEVEL III

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FINAL SURVEY STUDY

for

GREAT LAKES and ST. LAWRENCE SEAWAY NAVIGATION SEASON EXTENSION

VOLUME IV

APPENDIXES D - F

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U.S. ARMY ENGINEER DISTRICT, DETROIT
CORPS OF ENGINEERS
DETROIT, MICHIGAN

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This is the Final Report for the Great Lakes and St. Lawrence Seaway Navigation Season Extension feasibility study. The goal of this study is to consider the feasibility of means of extending the navigation season on the entire system from mid-December to early April (year-round). The report uses, as a base condition, the Chief of Engineers 16 November 1977 report which recommends the extension of the navigation season on the upper four Great Lakes to 31 January (± 2 weeks). The purpose of this study is to determine whether

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Federal participation in Navigation Season Extension is desirable, and its extent, if any, to address the significant social, environmental, economic, engineering, and institutional aspects, and, to make a recommendation for Congressional consideration based on these findings.

This Final Report evaluates six proposals, considering various season lengths and geographic coverages, to further extend the navigation season on the entire Great Lakes/St. Lawrence Seaway System up to 12 months on the upper four Great Lakes, and up to 11 months on the Welland Canal, Lake Ontario and the International Section of the St. Lawrence River. This report relates U. S. costs to U. S. Benefits.

This study concludes that season extension is engineeringly and economically feasible year-round on the upper three Great Lakes, up to year-round on the St. Clair River-Lake St. Clair-Detroit River System and Lake Erie, and up to 10 months on Lake Ontario and the International Section of the St. Lawrence River. It is recognized that formal agreement with the Government of Canada is required for any extension on the system beyond the upper three Great Lakes. To assure and to confirm environmental and social feasibility of this program, an Environmental Plan of Action (EPOS) would be accomplished concurrently with implementation and execution of post-authorization planning, engineering, construction and operations with provisions to modify or stop the program if unacceptable environmental impacts surface. The District Engineer recommends that the project, as described above, be implemented.

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GREAT LAKES and ST. LAWRENCE SEAWAY

NAVIGATION SEASON EXTENSION

APPENDIXES

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AUGUST 1979
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APPENDIX D

ECONOMICS
BENEFITS AND COSTS

AUGUST 1979

APPENDIX D

ECONOMICS

BENEFITS AND COSTS

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APPENDIX D

ECONOMICS
BENEFITS AND COSTS

INTRODUCTION

This appendix discusses the benefits and costs associated with the proposals to extend the navigation season on the Great Lakes-St. Lawrence Seaway System, including the proposed plan of season extension. Benefits for proposals to extend the navigation season from 9 to 12 months on the Upper Great Lakes, and from 8 to 11 months on the St. Lawrence Seaway, are shown in monthly increments. Benefits are based on traffic projections over the selected 1990-2040 period of analysis. The forecasted tonnage levels and resulting benefits are cited in various tables in this appendix. Qualifications and assumptions are discussed in the text and in footnotes to the tables. Analyses of regional impact, intermodal impact, and energy impact are included in this appendix under the appropriate major topic heading.

Benefit-cost analysis is not as straightforward and simple as it may at first seem. There are often difficulties in precisely measuring the benefits and costs of a project, and in determining what costs and benefits should be included in the ratio.

In examining the benefit-cost analysis, it is important to distinguish between real benefits and costs and pecuniary benefits and costs. A benefit is real when it accrues to the final consummer of a public good or resource. Real benefits augment the social well being, and thus should be weighted against the real costs of a project. Pecuniary benefits and costs result from changes in relative prices that come about as the economy responds to the

project. Pecuniary benefits and costs change the distribution of income but do not represent a net gain or loss to the nation as a whole. Thus, pecuniary benefits and costs are a transfer of benefits and costs from one sector of the society and economy to another.

Following from this distinction, the benefits and costs of season extension were analyzed, based upon how improvements on the Great Lakes-St. Lawrence Seaway, resulting in more efficient transportation, will improve the National Economic Development, and thus benefit society as a whole. To this goal, all real quantifiable benefits and costs are included in the economic analysis. Pecuniary benefits and costs, while not a part of the benefit-cost ratio, are also discussed in this appendix.

REGULATIONS AND ASSUMPTIONS

The analyses of alternative plans to extend the navigation season were carried out under specific regulations and guidelines contained in a number of Congressional, Federal Water Resources Council, and U.S. Army Corps of Engineers directives. In addition, a number of key assumptions were necessary to define the parameters of the level and scope of study. Specific regulations and assumptions governing the economic analyses of Federal Water Resources projects are summarized below.

Regulations

Public Law 89-80 (22 July 1965) - The Water Resources Planning Act contained authority for establishing principles, standards, and procedures to formulate and evaluate Federal water and related land resources projects. On October 25, 1973 the principles and standards became effective and specify that the overall purpose of water and land resource planning is promotion of the quality of life, by

reflecting society's preferences for attainment of the following objectives:

National Economic Development, and

Environmental Quality

Public Law 89-670 (15 October 1966) - The Department of Transportation Act, Section 7(a), defined primary direct navigation benefits as, "the product of the savings to shippers using the waterway and the estimated traffic that would use the waterway; where the savings to shippers shall be construed to mean the difference between (a) the freight rates or charges prevailing at the time of the study for the movement by the alternative means, and (b) those which would be charged on the proposed waterway; and where the estimate of traffic that would use the waterway will be based on such freight rates, taking into account projections of the economic growth of the area."

Public Law 91-611 (31 December 1970) - Section 122 provides for consideration of possible adverse economic, social, and environmental effects of proposed projects.

Public Law 93-251 (7 March 1974) - Section 80, "(a) The interest rate formula to be used in plan formulation and evaluation for discounting future benefits and computing costs by Federal officers, employees, departments, agencies and instrumentalities in the preparation of comprehensive regional or river basin plans and the formulation and evaluation of Federal Water and related land resources projects shall be the formula set forth in the "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources" approved by the President on May 15, 1962 and published as Senate Document 97 of the 87th Congress on May 29, 1962, as amended by the regulation issued by the Water Resources Council and published in the

Federal Register on December 24, 1968 (33 F.R. 19170; 18 C.F.R. 704.39) until otherwise provided by a statute enacted after the date of enactment of this act. Everv provision of law and every administrative action in conflict with this section is hereby repealed to the extent of such conflict."

Assumptions

The projections of bulk and general cargo, upon which the economic analyses of benefits for navigation season extension are derived, are developed under the following assumptions:

a. there will be no major war or National economic depression;

b. all other factors being equal, traffic will move from producing areas to foreign and domestic areas of consumption over the most economical route;

c. prevailing rates for transportation services are fair and reasonable in comparison with costs incurred for providing the services;

d. no major dislocations will occur in the iron ore mining and steel producing locations;

e. the U.S. foreign policy will continue to facilitate grain exports to Europe, the Mediterranean and the Soviet Union;

f. growth in tons of general cargo overseas trade may be tied directly to growth of real dollar GNP; and

g. lock sizes and channel depth will remain unchanged but will continue to be maintained at their present level of efficiency.

THE GREAT LAKES TRAFFIC MODEL

Intended Use

The economic analysis in this appendix is based upon the Great Lakes-St. Lawrence Seaway (GL/SLS) Traffic Model. This model has been designed for and used in navigation studies such as season extension, connecting channels, and lock and harbor alternatives. The output of the model is in the form of tonnage forecasts. Navigation improvements lower the cost to users and stimulate traffic through improved service. The model measures the effect on tonnage levels of the improvements.

A benefit program then classifies benefits according to three categories. First, transportation savings are based on savings over the least cost alternative for traffic that is now able to use the previously winter-closed or capacity-constrained system. Second, stockpiling savings relate to the money and extra handling involved in keeping an extra inventory because the transportation system is closed. Thirdly, winter vessel utilization savings result from the offsetting of higher variable costs with spreading fixed costs over more delivered tonnage per ship. For example, a 10% increase in fuel, crew, and other operating costs is offset by 28% greater productivity in delivering tons by the vessel. The net result is an 8% decrease in the annual required freight rate for a 1,000' ship carrying iron ore from Two Harbors, Minnesota, to Gary, Indiana.

The Corps has used this model for the Maximum Ship Size Study and the Season Extension Program. The St. Lawrence Seaway Development Corporation has also used this tool in establishing the American position for toll negotiations with Canada. Wayne State University has used this model for an energy study contract with Argonne National Laboratories. Maritime Administration contractors are

making use of this model for their work in making Great Lakes forecasts of traffic. This work is also forming the data base for U.S.-Canadian joint studies of water levels and effects on navigation.

Methodology

The basic method of the model is the splitting of water transportation sensitive tonnage to the route with a favorable service and cost pattern. A small percentage of general cargo and a significant percentage of bulk cargo is reserved for the Great Lakes on the basis of long term legal contracts and ownership of feeder modes and facilities.

The key operating parts of the GL/SLS Traffic Model are Traffic Forecasts, Shipper Reaction Profile for Service, Transportation Rate File (Logistics Price File), and Lock Capacity Estimates. The resulting output is in the form of cargo projections. The model acts as a filter to remove from consideration that tonnage which the Great Lakes cannot compete for on a service and transportation rate basis. The relatively complex parts of each of the four main filters are discussed below.

Traffic Forecasts

The traffic forecasts are built into the model and classified into 22 bulk commodity groups such as coal and iron ore and 15 general cargo groups such as prime container food and machinery. The traffic projections are based on A. T. Kearney's Traffic Forecast Study conducted for North Central Division, Corps of Engineers.

The bulk forecasts were developed by Kearney from expert secondary sources such as Bureau of Mines and U.S. Department of

Agriculture. The utility needs of western coal were further refined by an interview program conducted by A. T. Kearney.

General cargo overseas traffic was based on projections of U.S. and foreign country Gross National Product (GNP). The relative significance of commodity groups and foreign area sensitivity to changes in incomes and prices (elasticity) is from a study by Synergy, Inc., for the Maritime Administration. A. T. Kearney provided high, medium and low growth rates for general cargo and bulk commodities. The medium bulk growth rates of about 2.0% were considered reasonable. The low general cargo rate of 4.75% was initially selected. Since November 1977 a rate of 3.3% for U.S. imports and 3.85% for U.S. exports was selected. The elasticity values have been readjusted so that the overall weighted value is equal to one.

Long term trends for the entire period 1890 through 1970 show an average annual increase of real GNP amounting to 3.3%. However, the decade 1960-1970 showed a higher rate of about 4.0% a year. The A. T. Kearney extrapolation of Data Resources, Inc., Summer 1975, Long Term Forecast shows U.S. Gross National Product forecast ranges from a high rate of 5.3% to 1980, and 3.8% for the period 1990-2040. This forecast was modified downward to reflect historic trends and the Data Resources, Fall 1977, forecast of around 3.3% growth to 1990. A U.S. GNP growth forecast of 3.3% was used in this work, with income elasticities of unity. These assumptions result in commodity growth rates of about 3.3% for general cargo.

Shipper Reaction Profile

The second operating part of the model is the shipper reaction profile which is part of the A. T. Kearney Traffic Forecast Study. Based on about 150 face-to-face interviews and a mail questionnaire

conducted by Kearney, shipper decision criteria regarding service was quantified. Each of the 37 commodity groups have a percentage setting at the current level for the item's season extension, container availability, reliability, and overseas shipment time. With a change to one of the three improvement levels the percentage that the Great Lakes can compete for is increased. The current level is set below 1.00 and the best level, which is in equal parity with coastal alternatives, is set at 1.00. The switches are interactive. For example, a .50 value for each of the four switches results in a cargo competitive factor of only .0625 (.5x.5x.5x.5).

Transportation Rate File

The third major working part of the GL/SLS Traffic Model is the Transportation Rate File (Logistics Price File). This file was recently completed by Booz, Allen & Hamilton under a contract with North Central Division, Corps of Engineers. The key variables regarding rates are distance, value, cubic space occupied (stowage factor), and conference or rate territory. Rate calculator formulas were used to develop a reliable complete file of rates for 6,800 Origin/Destination/Commodity trading partners. These rates include the land feeder port charges and water rate for both the Great Lakes and coastal alternative. Of the traffic that can be competed for on a rate basis, the Great Lakes can capture about two-thirds of the potential remaining after service factor reductions.

This file of transportation rates can be modified by the Winter Rate Study factors for the Great Lakes water leg for domestic and overseas traffic. This Winter Rate Study was conducted by ARCTEC, Inc., for North Central Division, Corps of Engineers. A special switch has also been programmed into the model to reflect tolls and user charges, if applicable, for each lake node. Also, a technology switch can reflect changes in fleet mix and resulting ship required

freight rates. The Great Lakes charges for land feeder port costs, water leg, and total can be directly modified.

Lock Capacity Estimates

The Corps has developed an interactive program that takes into account flows exclusive to one lock node and that are dependent upon other lock nodes. The lock capacity estimates are based on the Lock Capacity Study conducted by ARCTEC, Inc., for the North Central Division, Corps of Engineers. The lock capacity estimates are defined in absolute tons, by decade, and they take into consideration future changes in fleet mix. Commodity mix changes are not lost because of the absolute tonnage constraint currently utilized in the model. All traffic available in the year of analysis has an equal chance of moving through the capacity constrained nodes.

Input Data Needs

1972 was selected as the year for the model from the following transport data:

a. Corps of Engineers waterborne commerce Bureau of Economic Analysis (BEA) to BEA statistics;

b. Department of Transportation 1% Interstate Commerce Commission (ICC) Waybill Sample for rail movements;

c. Bureau of Census Foreign Trade Statistics showing U.S. waterborne commerce by port, customs district, and world area;

d. Canadian Shipping Statistics; and

e. Corps of Engineers and Department of Transportation sponsored Bureau of Census Domestic and International Transportation of U.S. Foreign Trade: 1970.

Work underway by the Office of the Chief of Engineers (OCE) and Institute of Water Resources (IWR) will provide updates of above information. The Waterborne Commerce Center can be asked to update Great Lakes BEA to BEA flows as needed. The basic origin/destination flow data and commodity projections, as recently modified by the Corps, are considered adequate for the next few years. The shipper reaction profile data base will be improved and updated in FY 79-81 as funds become available. The Logistics Price File was recently completed by Booz-Allen and will not need a major update for five years. Booz-Allen has provided, as part of their contract, some limited update suggestions for year-to-year changes. The lock capacity estimates are based on ARCTEC's January 1979 Lock Capacity Study.

Assumptions

A key traffic flow assumption is that growth in tons in general cargo overseas trade is directly tied to growth of real dollar GNP. The background for this assumption is documented in the A. T. Kearney reports along with scenario developments based on market demand for steel, and legislative items such as the effect of enforcement of the 1970 Clean Air Act on coal production.

The shipper reaction profile assumptions are based on the expert judgment of contractor A. T. Kearney used to translate interview opinions into a service criteria percentage for each commodity group. This is a state of the art estimate which will be improved by MARAD and Corps research that can be adapted to an Automatic Data Processing (ADP) format.

The logistics price file represents a major jump in the state of the art in transportation economics. This file accurately presents the relative difference between the Great Lakes and alternative modes

within plus or minus 2%. This is the critical measure of tonnage flow split and benefit determination. The predictability of absolute rates has a higher level of error but the relevant result is the comparison between the Great Lakes and alternative mode. Use of rates conforms with Section 7A of P.L. 89-670 which established the Department of Transportation on October 15, 1966.

Processing of Data and Output Formats

Forecasts of bulk cargo and general cargo are loaded into the model. These forecasts can be accepted or overridden as the analyst sees fit. These forecasts before processing have output format names of "Totalup" and "Lumpit." "Totalup" produces a report which lists for each Origin/Destination/Commodity (O/D/C) the seven years of medium forecasts, and total base year flow with the lake route part by commodity and origin area. "Lumpit" totals certain groupings of origins and destinations. The forecast file goes to the route split program which assesses the shipper reaction profile. The route split program then compares the remaining traffic with the Logistics Price File and any specific rate switches. The two output formats are "Detail" and "Aggregate."

The program "Detail" generates reports for eight combinations or one origin/destination or commodity group. The user of the program "Aggregate" can obtain a report for the flow of any commodity, or aggregation of commodities, through any or all lake nodes.

Summary

The GL/SLS Traffic Model is an essential planning tool for a project of this size and scope. The four major elements of the model (Traffic Forecasts, Shipper Reaction Profile for Service, Transportation Rate File, and Lock Capacity Estimates) are

periodically restudied, updated and refined to keep it current, thus insuring the accuracy and quality of the analysis.

Following is a list of the four fundamental studies, and the respective consultants, which were conducted in developing the GL/SLS Traffic Model.

1. GL/SLS Traffic Forecast Study, by A. T. Kearney, Inc., Chicago, Illinois;

2. Development of a Logistics Price File, by Booz, Allen & Hamilton, Inc., Bethesda, Maryland;

3. Winter Rate Study for GL/SLS System, by ARCTEC, Inc., Columbia, Maryland;

4. GL/SLS Lock Capacity Analysis, by ARCTEC, Inc., Columbia, Maryland.

BENEFITS FROM SEASON EXTENSION

General

The primary measure of benefits occuring from water resource development projects are measured according to National Economic Development (NED) objectives. Specifically, benefits must represent an increase in the value of the nations's output of goods and services and improve national economic efficiency. When sucn benefits are created through water resource development, they are measured in terms of their value to the user. The primary direct navigation benefits of a water resource project are measured in a comparison of savings to shippers based upon transportation rates with and without the project.

Principles and Standards

In addition to the NED goals of water resources development projects are objectives of environmental quality, social well-being and regional development. The environmental quality (EQ) objective is enhanced by the management, conservation, preservation, creation, restoration or improvement of the quality of natural and cultural resources and ecological systems in the area under study. Social well-being refers to contributions made by a project toward the equitable distribution of real income and employment and to other social opportunitites. The regional development objective includes impact of a project on regional income, employment, population distribution, diversification of the regional economic base and environmental conditions of special regional concern. Benefits may be stated in terms of positive effects and in terms of dis-benefits or negative impacts brought about by the project.

In constructing the benefit/cost index or ratio a netting out process is conducted wherein benefits meeting the criteria of adding value to the nations's output of goods and services are compared with relative development costs including environmental costs of the project. Positive and negative impacts of regional development and social well-being accounts are displayed and quantified to the extent feasible. These are pecuniary benefits and costs and while one sector of the economy or society benefits, others may lose; however, there is no net gain or loss to NED or society as a whole. Hence, only the benefits and cost in the NED and EQ accounts are compiled for benefit-cost comparison in determining a projects contribution to the nation. A positive benefit to cost ratio, greater than unity, is normally required for favorable project recommendations.

Project benefits are measured over the economic life of a project, normally 50-years. Costs on the other hand are incurred early in the project life, normally in the first decade. Proper

comparison of costs with benefits that will change over time requires that both costs and benefits be on an equivalent time basis. Discounting benefits and costs to a comparable basis is accomplished by reducing each to an average annual series. An interest rate, presently 7-1/8%, is applied to establish the present worth of benefits and costs for comparative purposes.

ECONOMICS STUDY APPROACH

This appendix is organized along the lines of the study approach shown in Figure 1. Each of the component parts represent an independent study effort to establish the key parameters leading to the determination of National Economic Development Benefits and Regional Development Impacts of Great Lakes-St. Lawrence Seaway Navigation Season Extension.

Total Region Transport Demand

A Great Lakes hinterland was defined in the United States, which included 19 states, and portions of other states immediately surrounding the Great Lakes (See Figure 2). U.S. movements which originate and/or terminate within this hinterland area were examined in establishing the total region transport demand.

Thirty-seven commodity groupings were used as the basis for the forecasts (See Table 1). Commodities are grouped into two major categories, bulk and general cargo.

Ten Canadian regions were defined, eight of which corresponded to various segments of the GL/SLS. Eighteen overseas regions were also defined. Of principal concern for the Great Lakes are the United Kingdom, Northern Europe, Mediterranean Europe, North Africa and Japan. (Projections were developed on a by decade basis from 1990 through 2040, the period of analysis for the survey study.)

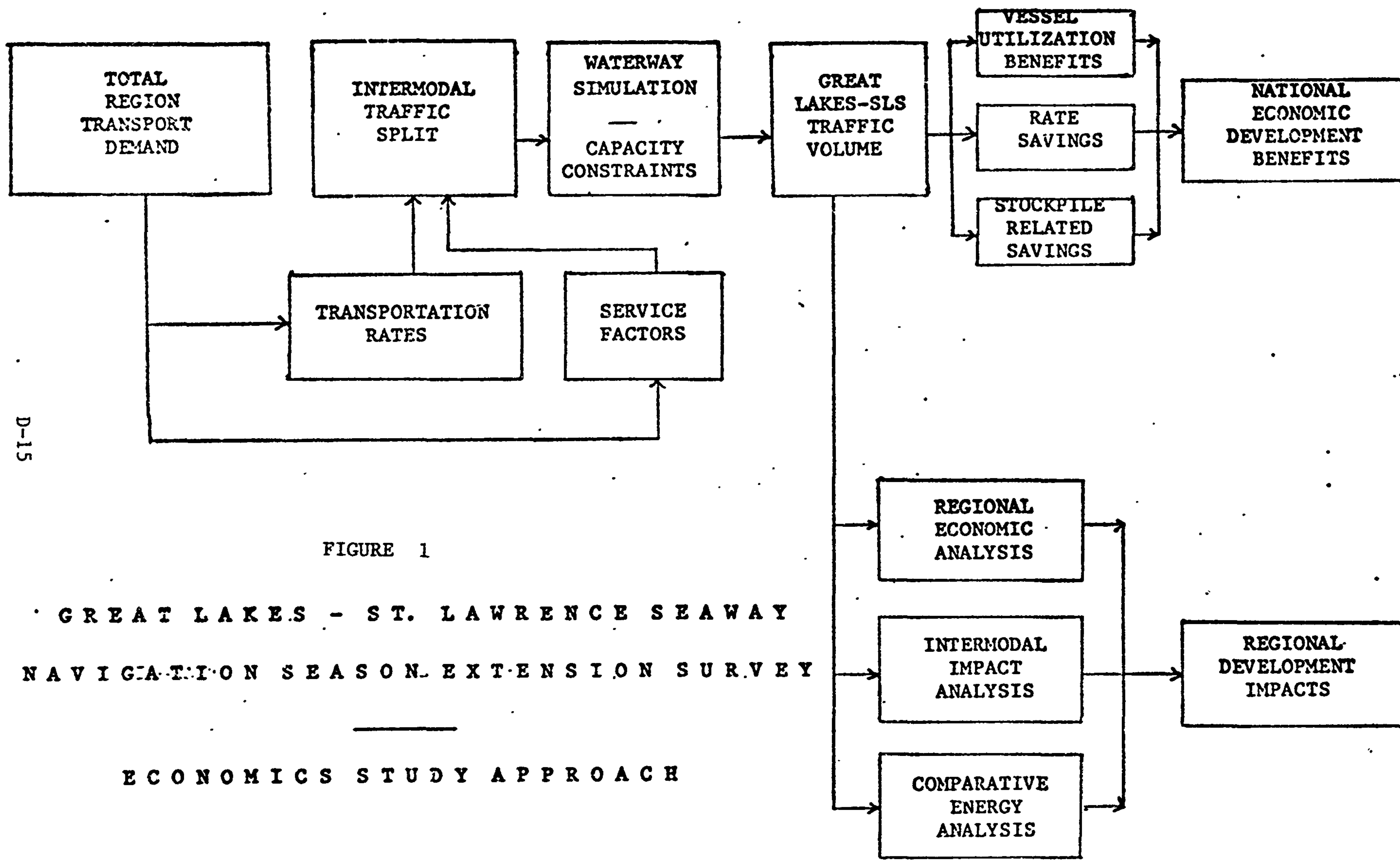


FIGURE 1

GREAT LAKES - ST. LAWRENCE SEAWAY

NAVIGATION SEASON EXTENSION SURVEY

ECONOMICS STUDY APPROACH

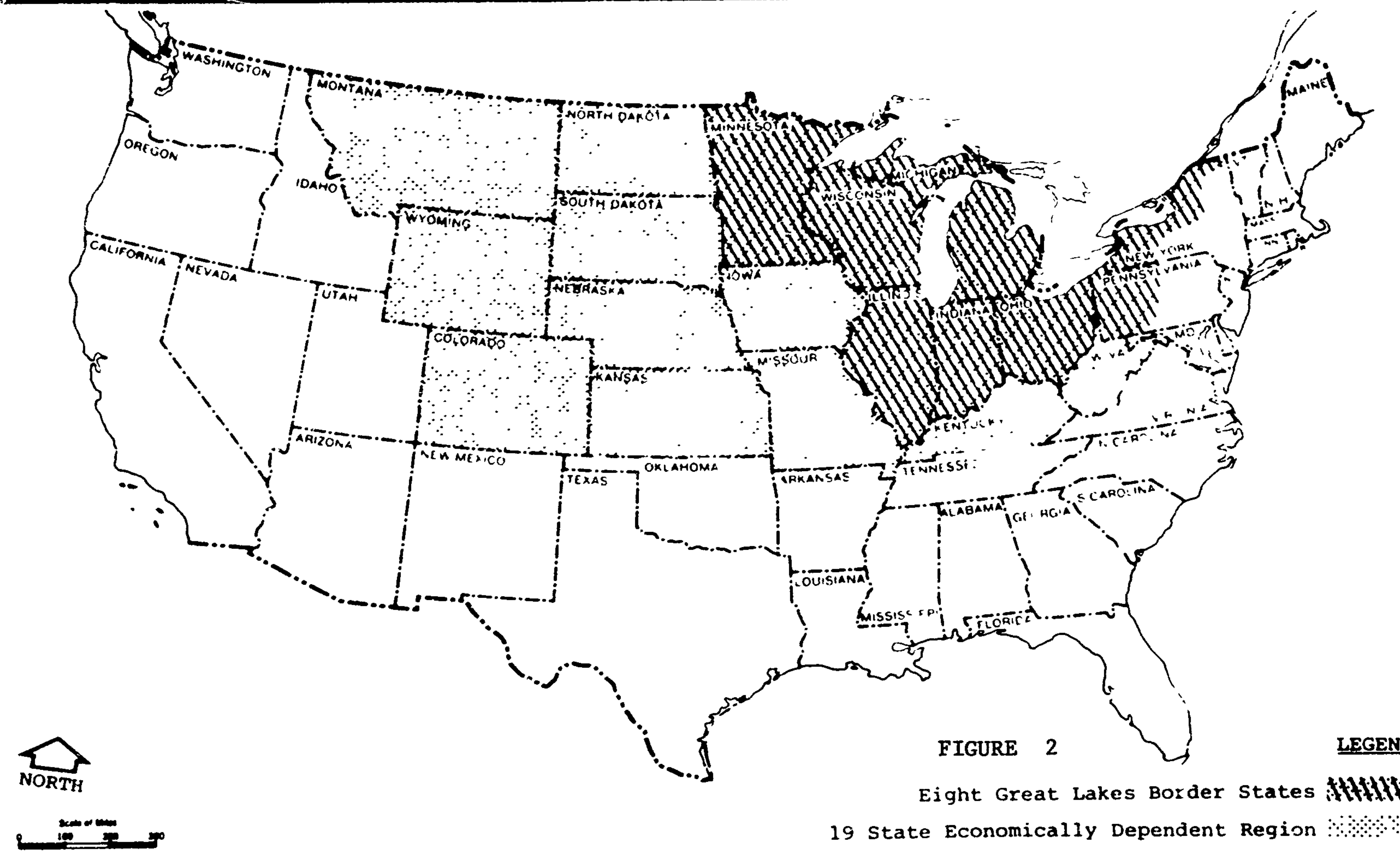


FIGURE 2

LEGEND

Eight Great Lakes Border States

19 State Economically Dependent Region

GREAT LAKES ECONOMIC REGION

TABLE 1

GL/SLS COMMODITY CLASSIFICATIONS

Commodity Group	1.0 Bulk Commodities	BOB SIC CODES	WCC CODES	IMPORTS SCHEDULE A	EXPORTS SCHEDULE B
	1.1 Grain and Other Farm Produce				
1	1.11 Corn	0113	0103	044.0	044.0
2	1.12 Wheat	0113	0107	041.0	041.0
3	1.13 Soybeans	0113	0111	221.4	221.4
4	1.14 Barley and Rye	0113	0102	043.0, 045.1	043.0, 045.1
5	1.15 Other Cash Grain				
	Oats	0113	0104	045.2	045.2
	Rice	0113	0105	042.1, 042.2	042.1, 042.2
	Sorghum	0113	0106	045.9	045.9
6	1.16 Other Farm Produce				
	Cotton, Raw	0112	0101	263.1-263.5	263.1-263.5
	Flaxseed	0119	0112	221.5	221.5
	Oilseeds, NEC	0119	0119	221.1-221.3, 221.6-221.8	221.0, 221.1, 221.6, 221.9
	Tobacco, Leaf	0114	0121	121.0	121.0
	Hay and Fodder	0119	0122	081.1	081.1
	Field Crops, NEC	0119	0129	-	-
	Fresh Fruits and Tree Nuts	0122	0131	051.1-053.8, ex. 051.3	051.1-053.9, ex 051.3
	Bananas and Plantains	(1)	0132	051.3	051.3
	Coffee	(1)	0133	071.1-071.3	071.1-071.3
	Cocoa Beans	(1)	0134	072.1-073.0	072.1-073.0
	Live Animals	0141	0151	001.1-001.8, 941.0	001.1-001.9, 941.0
	Animals and Products, NEC	2011	0161	211.1-212.0	211.1-212.0
	Miscellaneous Farm Products	0199	0191	292.2-292.9	292.2-292.9
	Tallow, Animal Fats and Oils	2094	2014	-	-
7	1.2 Coal	1213	1121	321.4, 321.7, 321.9	321.4, 321.7, 321.9
	1.3 Petroleum and Petroleum Products				
8	1.31 Crude Petroleum	1311	1311	331.0	331.0
9	1.32 Fuels				
	Gasoline	2911	2911	332.1	332.1
	Jet Fuel	2911	2912	332.2	332.2
	Kerosene	2911	2913	332.2	332.2
	Distillate Fuel Oil	2911	2914	332.3	332.3
	Residual Fuel Oil	2911	2915	332.4	332.4
10	1.33 Other Petroleum Products				
	Naptha, Petroleum Solvents	2911	2917	-	-
	Asphalt, Tar and Pitches	2911	2918	332.9	332.9
	Asphalt Building Materials	2951	2951	661.8	661.8
	Petroleum and Coal Products, NEC	2999	2991	341.0	341.1, 341.2

(1) Not shown in Bureau of Budget SIC Classifications.

(2) Commodity classifications cross referenced for the 37 commodity groupings used in this study with the various codes used for statistical reporting. These include:

1. SIC Codes.
2. WCSC Codes (Corps of Engineers).
3. Schedule A Codes (Bureau of Census - Imports).

TABLE 1 (Cont'd)
GL/SLS COMMODITY CLASSIFICATIONS

Commodity Group	1.0 Bulk Commodities	BOB SIC CODES	WCC CODES	IMPORTS SCHEDULE A	EXPORTS SCHEDULE B
	1.4 Mining and quarrying of Nonmetallic Minerals except Fuels				
11	1.41 Limestone	1411	1411	273.2	273.2
12	1.42 Building Cement	3241	3241	661.2	661.2
13	1.43 Salt	1476	1491	276.3	276.3
14	1.44 Other Building Materials				
	Building Stone, Uncrushed	1411	1412	273.1	273.1
	Sand, Gravel, Crushed Rock	1442	1442	273.3, 273.4	273.3, 273.4
	Clay	1453	1451	276.2	276.2
	Gypsum, Crude and Plasters	1492	1494	Included in Limestone	Included in Limestone
	Cut Stone and Stone Products	3281	3281	661.3	661.3
15	1.45 Other Mined Products				
	Phosphate Rock	1475	1471	271.3	271.3
	Natural Fertilizer Materials, NEC	1479	1479	271.2, 271.4	271.1, 271.2, 271.4
	Sulphur, Dry	1477	1492	274.2, 274.3	274.1, 274.2
	Sulphur, Liquid	1477	1493		
	Nonmetallic Minerals, NEC	1499	1499	275.1, 275.2, 276.4-276.5 276.9	275.1, 275.2, 276.4-276.5 276.9
	1.5 Metal Mining				
16	1.51 Iron Ore and Concentrates	1011	1011	281.0	281.3, 281.4
17	1.52 Other Ores				
	Copper Ore and Concentrates	1021	1021	283.1	283.1
	Aluminum Ores	1051	1051	283.3	283.3
	Manganese Ores	1062	1061	283.7	283.7
	Nonferrous Ores, Concentrates, NEC	1099	1091	283.2, 283.4-283.6 283.9, 285.0, 286.0	283.8, 283.9, 285.0, 286.0
	1.6 Non-gravity Flow Bulk Commodities (Substantial Flows)				
18	1.61 Iron and Steel Scrap	3391	4011	282.0	282.0
19	1.62 Standard Newsprint Paper	2621	2621	641.1	641.1
20	1.63 Coke, Petroleum Coke	2911	2920	321.8	321.8
21	1.64 Pulp	2611	2611	251.2-251.8	251.3-251.8

TABLE 1 (Cont'd)
GL/SLS COMMODITY CLASSIFICATIONS

Commodity Group	1.0 Bulk Commodities	BOB SIC CODES	WCC CODES	IMPORTS SCHEDULE A	EXPORTS SCHEDULE B
22	1.7 All Other Bulk				
	Crude Rubber and Allied Gums	0842	0841	231.1-231.5	231.1-231.4
	Forest Products, NEC	0861	0861	-	-
	Sugar	206	2061	061.3, 061.6-062.0	061.3, 061.6-062.0
	Logs	2411	2411		
	Rafted Logs	2411	2412		
	Gum and Wood Chemicals	2861	2413		
	Timber, Posts, Poles, Piling	2411	2414	241.1-244.0 except 243.2 243.3	241.1-244.0, except 243.2, 243.3
	Pulpwood, Log	2411	2415		
	Wood Chips, Staves, Moldings	2431	2416		
	Pulp and Paper Products, NEC	2649	2691		
	Crude Tar, Oil, Gas Products	2815	2811	521.1-521.5	521.1-521.3
	Liquefied Gases	2911	2921	-	-
	Lime	3274	3271	661.1	661.1
	Slag	3312	3312	276.6	276.6
	Coke, Pet Asphalts, Solvents	3312	3313	-	-
	Nonferrous Metals, NEC	3339	3321		
	Nonferrous Metal Scrap	3341	4012	284.0, 284.1	284.0
	Textile Waste, Scrap, Sweep	2294	4022		267.0
	Paper Waste and Scrap	2611	4024	251.1	251.1
	Commodities, NEC	(1)	4112	-	-
	Waterway Improvement Materials	(1)	4118	-	-
	Department of Defense & Science	(1)	9999	951.0	951.0-952.0
	2.0 General Cargo				
	2.1 Prime Cargo for Containerization				
23	2.11 Food and Kindred Products				
	Fresh and Frozen Vegetables	0123	0141	054.1-055.5	054.1-055.5
	Fresh Fish, Except Shellfish	0912	0911	031.1, 031.2	031.1, 031.2
	Meat, Fresh, Chilled, Frozen	201	2011	011.1-011.9	011.1-011.9
	Meat and Products, NEC	201	2012	012.1-013.9	012.1-013.8
	Animal By-Products, NEC	201	2015	291.1, 291.9	291.0
	Dairy Products, NEC	202	2021	022.1, 022.3-025.0	022.1, 022.3-025.0
	Dried Milk and Cream	202	2022	022.2	022.2
	Fish and Shellfish, Prepared	2031 &) 2036)	(2031	031.3, 032.0	032.0, 031.3
	Vegetables and Prep., NEC	2032-35)	(2034	-	-
	Prep. Fruit & Vegetable Juice, NEC	2037)	(2039	111.0	111.0
	Alcoholic Beverages	208	2081	112.1-112.4	112.1-112.4
	Miscellaneous Food Products	2099	2099	099.0, 074.1-075.2	099.0-099.9, 074.1-075.2

(1) Not shown in Bureau of Budget SIC Classifications.

TABLE 1 (Cont'd)
GL/SLS COMMODITY CLASSIFICATIONS

Commodity Group	2.0 General Cargo	BOB SIC CODES	WCC CODES	IMPORTS SCHEDULE A	EXPORTS SCHEDULE B
24	2.12 Chemicals				
	Plastic Materials	2821	2821		
	Synthetic Rubber	2822	2822	581.3-581.9	581.1-581.9
	Synthetic (Man-Made) Fibers	2823-24	2823	-	
	Drugs	283	2831	541.1-541.9	541.1-541.9
	Soap	284	2841	554.1-554.3	554.1-554.3
	Paints	2851	2851	533.3	533.3
	Gum and Wood Chemicals	2861	2861	599.6	599.6
25	2.13 Fabricated Metal Products	34	3411	691.1-698.9	691.1-698.9
26	2.14 All Other				
	Tobacco Manufacturers	21	2111	122.1-122.3	122.1-122.3
	Basic Textile Products	22	2211	261.1-262.9, 264.0-266.4	261.0-262.9, 264.0-266.4
	Textile Fibers, NEC	22	2212	651.0-657.8	651.1-657.8
	Apparel	23	2311	831.0-851.0	831.0-851.0
	Furniture and Fixtures	25	2511	821.0, 812.4	821.0, 812.4
	Printed Matter	27	2711	892.1-892.9	892.1-892.9
	Rubber and Miscellaneous Plastic Products	30	3011	629.1-629.4	621.0-629.9
	Leather and Leather Products	31	3111	611.2-613.0	611.2-613.0
	Glass and Glass Products	321-3	3211	664.1-665.3	664.1-665.8
	Instruments, Time, Photo, Optical Goods	38	3811	861.1-864.2	861.1-864.3
	Miscellaneous Manufactured Products	39	3911	891.1-891.9, 893.1-899.9 812.2-812.3	891.1-891.9, 893.0-899.9 812.1-812.3
27	2.2 Potentially Containerized Cargo				
	2.21 Food and Kindred Products				
	Wheat Flour and Semolina	2041	2041	-	046.0
	Prepared Animal Feeds	2042	2042	081.2-081.9	081.2-081.9
	Grain Mill Products, NEC	2043-46	2049	-	-
	Molasses	206	2062	061.5	061.5
	Vegetable Oils, Margarine, Shortening	2091-3) 2096)	(2091)	091.0, 421.2-431.5	091.3, 091.4, 421.2-431.5
	Animal Oils and Fats, NEC	2094	2092	411.1, 411.3	411.1, 411.3
	Groceries	(1)	2094	048.1-048.8	047.0-048.8
	Ice	2097	2095	-	-
28	2.22 Chemicals				
	Sodium Hydroxide	2812	2810	See Chemicals - N.E.C.	See Chemicals - N.E.C.
	Dyes, Pigment, Tanning Materials	2815	2812	292.1, 531.0-533.2	531.0-533.2
	Alcohols	2818	2813	See Chemicals - N.E.C.	See Chemicals - N.E.C.
	Radioactive Materials, Wastes	2819	2816	515.0	515.1-515.3
	Benzene and Toluene	2815	2817	-	521.4
	Sulphuric Acid	2819	2818	See Chemicals - N.E.C.	See Chemicals - N.E.C.
	Basic Chemicals and Products, NEC	2818-19	2819	512.0-514.0, 599.5, 599.7, 599.9	512.0-514.8, 599.5 599.7, 599.9
	Fertilizer and Materials, NEC	2871	2879	561.9	561.9
	Miscellaneous Chemical Products	2899	2891	551.1-553.0	551.1-553.0
	Insecticides, Disinfectants	2879	2876	599.2	599.2

TABLE 1 (Cont'd)
GL/SLS COMMODITY CLASSIFICATIONS

Commodity Group	2.0 General Cargo	BOB SIC CODES	WCC CODES	IMPORTS SCHEDULE A	EXPORTS SCHEDULE B
29	2.23 Iron and Steel Products				
	Iron and Steel Primary Forms	3312	3314	672.1-672.4, 671.3	672.1-672.9, 671.3
	Iron, Steel Shapes, Except Sheet	3312	3315	673.1-673.5	673.1-673.5
	Iron and Steel Plates, Sheets	3316	3316	674.1-674.C	674.4-674.8
	Iron and Steel Pipe and Tube	3317	3317	678.1-678.6	678.1-678.5
	Iron and Steel Products, NEC	3313 &) 15)	(3319	675.0-677.0, 679.1-679.3	675.0, 676.1-676.2, 677.0, 679.1, 679
	Ferralloys	3323	3318	671.4, 671.5	671.4, 671.5
30	2.24 Machinery, except Electrical	35	3511	711.1-719.9	711.1-719.9
31	2.25 Electrical Machinery and Equipment	36	3611	722.1-729.9	722.1-729.9
32	2.26 Motor Vehicles, Parts, Equipment	371	3711	732.1-732.9	732.0-732.9
33	2.27 All Other				
	Ordnance and Accessories	191	1911	571.1-571.4	571.1-571.4
	Lumber	24	2421	243.2, 243.3	243.2, 243.3
	Veneer, Plywood, Worked Wood	2432	2431	631.1-631.8	631.1-631.8
	Wood Manufacturing, NEC	2499	2491	632.1-633.0	632.1-633.0
	Paper and Paperboard	262-5	2631	641.2-642.9	641.2-642.9
	Lubricating Oils and Greases	2992	2916	332.5, 332.6	332.5, 332.6
	Structural Clay Products	325	3251	662.3-662.4	662.3-662.4
	Miscellaneous Nonmetallic Mineral Products	3299	3291	663.1-663.9, 666.4-667.4	663.1-663.9, 666.4-667.4
	Copper Alloys, Unworked	3331	3322	682.1-682.2	682.1, 682.2
	Lead and Zinc, Unworked	3332-3	3323	685.1-686.2	685.1-686.2
	Aluminum and Alloys, Unworked	3334	3324	684.1-684.2	684.0-684.2
	Aircarft and Parts	372	3721	734.1-734.9	734.1-734.9
	Miscellaneous Transportation Equipment	374 & 5) & 9)	(3791	731.0-731.7, 733.1, 733.3	731.0-731.7, 733.1-733.4
	All Other Nonferrous Alloys	-	-	681.1-681.2, 683.1-683.2 687.1-689.5	681.1, 681.2, 683.1, 683.2, 687.1-689.5
	2.3 Not Susceptible to Container				
34	2.31 Chemicals				
	Nitrogenous Chemical Fertilizers	2871	2871	561.4	561.1
	Potassic Chemical Fertilizers	2871	2872	561.3	561.3
	Phosphatic Chemical Fertilizers	2871	2873	561.2	561.2
35	2.32 Pig Iron	3312	3311	671.1-671.2	671.1-671.2
36	3 All Other				
	ips and Boats	373	3731	735.0	735.4-735.9
37	3.0 Not Classified According to Kind	-	-	931.1, 990.0	931.0, 961.0

Transportation Rates

There are over 6,800 individual origin/destination traffic movements in the GL/SLS 19-state tributary area. Utilizing a file of approximately 2,000 actual rates, a total file of 17,000 rates was established to account for multi-mode and multi-route traffic movements.

The basic methodology for developing the 17,000 through rates in the rate file involved two principal phases. The first phase was development of a rate calculator formula capable of producing any land or water freight rate based on the origin and destination points of the movement and the characteristics of the commodity. This formula consists of a series of rate calculator equations developed by regression analysis of the 2,000 actual freight rates. These equations are supplemented with a file of rates for a limited number of movements which were not subjected to statistical analysis. These movements consist of bulk commodities, such as iron ore, coal and some grains which have few origin-destination points. Actual freight rates were collected for these selected bulk commodities. The second phase of the approach involved developing techniques to use the rate calculator formula to produce through rates compatible with the geographic and commodity specifications of the GL/SLS tributary area and reflecting current rate differentials for competitive routes.

Since the physical conditions of navigation season extension vary from the current April-December season, a secondary rate study was made to establish the relativity between winter navigation and the so-called normal shipping season. The purpose of this is:

a. to estimate the total transit time for ships navigating a technically feasible Great Lakes/St. Lawrence Seaway System during

the winter season and translate these total transit times into vessel operating costs and the associated required freight rates for the major commodity routes; and

b. to estimate the effect on required freight rates of:

1. Length of the Navigation Season
2. Winter Severity
3. Vessel Fleet Mix
4. Improvement Levels

The rate file was then adjusted to establish both a normal and winter season rate for application to traffic projected to move during the two respective periods.

Service Factors

As a means of equating transport rates with less quantitative factors to determine the GL/SLS competitive position with respect to other transport routes, an analysis was made of a number of service factors. A sensitivity range of indices was established which permits analysis of the traffic related effects of varying degrees of navigation season extension, service reliability, shipment time and availability of containerized services. These service factors (given a specific weight) selectively affect the GL/SLS competitive position and when applied to respective rates for alternative route comparisons influence the extent to which the GL/SLS can compete with the alternate route on the basis of adjusted rates (as contained in the rate file).

The results of a shipper preference survey indicated that the following factors are among the most often considered in making routing decisions:

a. total cost of transportation, including implicitly or explicitly, the time value of goods-in-transit;

b. service continuity including consideration of year-round availability, service loyalty, reputation and past dealings;

c. sailing frequency;

d. total transit time;

e. service reliability;

f. availability of special services such as container services (most often cited), "roll on-roll off" services, heavy-lift capability, etc; and

g. port operation considerations such as congestion avoidance, efficiency, degree of special service accommodation, etc.

Based on the survey findings noted above, service factors were defined for:

a. service continuity (length of season);

b. shipment time, including combined effects of sailing frequency and transit time;

c. service reliability (both schedule and handling); and

d. degree of containerization (and all that it implies).

The effect of the application of service factors is to identify a portion (0-100%) of the total origin/destination flow for which the

GL/SLS cannot effectively compete (assuming certain conditions such as an eight month season, etc.). Thus, service factor comparisons are made for the GL/SLS and for alternate routes. Implicitly then, the GL/SLS routes are, in a service sense, considered equal or less attractive than the alternate. Hence, some traffic for which GL/SLS ports have equal or favorable rate differentials is not considered potential as a result of service factor disadvantages.

The extent to which shippers are sensitive to service factors varies, in the first degree, by specific commodity or commodity group. Within commodity groups, shippers react in response to unique sets of circumstances such as market position, economic conditions, competitive posture, etc.

Intermodal Traffic Split

Commodity flow forecasts were developed which identify all movements which may have a favorable advantage for origin or destination in the Great Lakes hinterland, the 19-state geographic area served by the Great Lakes system. The modal split between the GL/SLS and other routes was made on the basis of the service and cost attributes to allocate those flows to either a Great Lakes or an alternative routing.

Developed and illustrated in the report are: (1) tributary area traffic generated, and (2) tributary area traffic for which there is a GL/SLS rate/service factor competitive advantage.

Water Simulation - Capacity Constraints

Once the volume of traffic with a GL/SLS competitive advantage was established, the capability of the system to handle the traffic was tested. The capacity of any navigation system, such as the Great

Lakes/St. Lawrence Seaway (GL/SLS) Navigation System, is determined by the system's limiting or constraining element; that is, its slowest processing element. For the GL/SLS Navigation System, which extends over 2,000 miles from Duluth-Superior at the western end of Lake Superior to the Gulf of St. Lawrence and the Atlantic Ocean, and has over 40 commercial harbors and numerous trade routes which use the three lock systems (Soo, Welland, and Seaway), the constraining elements in the system are the locks. As the annual tonnage on the GL/SLS System increases, the demand for service (tonnage to be transported) at these three lock complexes will increase and vessels would be expected to experience longer waiting times and longer vessel queues as capacity is approached. Such constraints further reduce the amount of traffic the system may attract and, hence, have a direct effect on the benefits of navigation related projects.

The GL/SLS Navigation Season Extension serves to increase lock capacity by allowing some commodities to be shifted from normal to winter months. On the other hand, the added service capabilities reflected in the increase from 8-months up to a maximum of 12-months would be expected to have the effect of inducing more traffic in the system throughout the months and, thus, increase future system demand with further impact on practical capacity.

Overall, the GL/SLS LOCK CAPACITY MODEL is described as a queuing model which analyzes steady-state lock operations and vessel-lock interaction. Inputting data on traffic projections, vessel fleet and lock operations for each specific year, the GL/SLS LOCK CAPACITY MODEL generates output for 14 separate time periods (10 months plus early and late April, and early and late December) showing:

a. cargo transported by commodity and direction;

b. vessel operating fleet;

c. yearly vessel transit demand by vessel class, commodity, and direction;

d. daily vessel transit demand by vessel class and direction;

e. lock cycle time by direction (mean and standard deviation);

f. average vessel waiting time by direction;

g. average vessel queue length by direction;

h. lock utilization; and,

i. vessel delay costs.

Using this output, an independent decision is then made as to whether or not a capacity condition has occurred, based on a prescribed capacity criteria such as: average vessel waiting time, average vessel queue length, and lock utilization.

Great Lakes/SLS Traffic Volume

At this point in the study of the economics of GL/SLS Navigation Season Extension, total traffic generated in the system has been reduced to traffic with competitive rate/service factor advantage which is further tested for system capacity constraints. The remaining traffic volume projected over the 1990-2040 study period, truncated at the point of lock capacity constraint, is the basis for consideration of National Economic Development Benefits resulting from GL/SLS Navigation Season Extension and is also the basis for examining Regional Development Impacts of any recommended project.

Rate Savings

Substantial transportation rate savings would result from extending the navigation season on the Great Lakes/St. Lawrence Seaway System (GL/SLS). Shippers of GL/SLS waterborne commerce will have the less costly water transportation alternative open to them for an extended period. This would result in transportation rate savings reflecting the differentials between GL/SLS waterborne rates and alternative overland rates.

Winter Rate Savings

The second major area of savings stems rrom the more efficient utilization of the existing Great Lakes fleet mix under both normal and winter operations. Navigation season extension provides a greater annual return on the capital invested in ships. Even though variable costs such as fuel and labor may increase with winter navigation, these increases are more than offset by increasing the number of loaded trips to spread capital costs over. Thus, whereas transportation rate savings result from a new least cost alternative defined in terms of existing waterborne and rail rate structures, winter rate savings result from efficiencies in using the current Great Lakes fleet, which lowers the annual freight rate for ships operating in the lakes.

Stockpile Related Benefits

Thirdly, users of bulk commodities such as iron ore and coal, which are transported on the Great Lakes during the 1 April to 15 December navigation season, stockpile resources for winter production needs in addition to contingency needs. Stockpiling savings which would result from a reliable winter supply include interest on capital invested in the stockpile inventory itself, and reduction of

handling costs incurred in stockpile management. Present stockpile volumes are approximately 30 million tons. Stockpile related benefits are valid for this potential traffic volume. Because of lock capacity constraints, benefits for potential future growth of stockpiled tonnage are curtailed at the point where capacity occurs. There will continue to be savings on potential stockpiled tonnage for traffic which would utilize Lake Michigan harbors such as Escanaba, which are not lock related. For this reason stockpile related benefits are divided into lock and non-lock related categories.

The derivation of these primary, transportation-related benefits attributable to navigation season extension is discussed in subsequent sections of this appendix.

Regional Development Impacts

As a supplement to the analysis of National Economic Development benefits, a series of interrelated studies were made on (1) regional economics, (2) intermodal impacts, and (3) comparative energy uses among transportation modes. Both positive and negative impacts are addressed on income, employment, population, and other related economic and social characteristics. Beneficial and adverse impacts reflect inter- and intra-regional shifts and transfers and, as such, are differentiated from the primary National Economic Development benefit analysis.

Because of the volume of data represented in the study approach outlined above and further discussed in following sections, summarization of study processes and results is necessary. A bibliography of references utilized in the economic studies is contained at the end of this appendix.

NATIONAL ECONOMIC DEVELOPMENT BENEFITS

The purpose of this section is to present a summary of the studies conducted investigating the method, development, and application of rate determination, traffic volume, and transportation routings along the Great Lakes/St. Lawrence Seaway (GL/SLS) system. This section also provides a description and rationale for the approach used in the economic study as well as the major assumptions and conclusions in the determination of the national economic development benefits. The focal point of this economic study are the forecasts of the commodity traffic that will travel through the GL/SLS system. There are three phases to these forecasts. The first phase is the construction of a forecast of the total regional demand for all modes of transportation. The second phase is to apply intermodal splits (separation of the total regional traffic into the various modes by which it will travel) upon the regional demand. The third phase is the application of the various lock capacity constraints to the forecast of the GL/SLS share of traffic. The product is a forecast of the capacity constrained GL/SLS traffic volume. It is this final traffic forecast, as well as a file of accurate competitive freight rates, that are the necessary elements to the determination of the National Economic Development benefits. This section will present the rationale and the findings of this approach.

Background

This study is but one of the many elements of the investigation of the impacts of winter navigation upon shipping on GL/SLS. The proposed improvements in navigation include such alternatives as season extension, channel, lock, and harbor modifications. These improvements will lower the cost basis for the users and stimulate traffic through improved service. The technical studies, which are the source material for this appendix, measure the effect of these

improvement alternatives. The improvements, or benefits, consist of an increase in traffic (tonnage level) due to a reduction in some aspect of the costs. These benefits will occur in three of the shipping processes. First, transportation savings are based upon savings over the least cost alternative for traffic which is now able to use the previously winter-closed or capacity-constrained system. Second, an increase in the navigation season will induce a reduction in stockpiling. This savings in stockpiling corresponds to a reduction in the costs of inventory handling and storage during the portion of the season when navigation is closed. Third, with the improvements each ship or vessel will deliver more tonnage per season. This will cause average variable cost to rise, but will also cause a greater (more than offsetting) reduction in average fixed costs. The result is a reduction in the average total costs.

Methodology

The objective of this study was to assess the benefits associated with specific improvements in navigation. The approach to this problem was to attempt to analyze, as best possible, the "real world" conditions. The approach of this study utilized both the quantitative and qualitative data that a shipper would normally use in the decision making process. The shipper's objective is to maximize profits and this will be accomplished by finding the route with the most favorable service and cost pattern.

In order to assess the impact of these future behavior patterns of the shippers the analytical approach has been broken down into its component parts. The key element of this study is the procedure by which the decision is made. The technique is, in a practical sense, a filter which removes from consideration those commodities which can potentially move on the Great Lakes, but cannot compete on a service and transportation rate (cost) basis.

This information which is required in the analytical process is traffic forecast, transportation costs, and service factors. After analyzing these factors a final check must be conducted upon the results of the process to insure that the GL/SLS system is able to accommodate the projected level of traffic. This is a check of the constraints upon the system. In particular, this is a check of the lock capacity of three lock systems on the Great Lakes.

TOTAL REGIONAL TRANSPORTATION DEMAND

The following discussion is a summary of the methodology used to develop the traffic forecasts. The methodology was developed specifically to identify the total potential traffic which could be routed through the GL/SLS system and what portion of that total potential is currently routed through the system. In addition, the forecasts developed in this section are not for all commodities, but for only those commodities which will be impacted by the season extension proposal for the GL/SLS system. The commodities included in the forecasts are grains (corn, wheat, soybeans, barley, rye, other grains, and other farm produce), coal, iron ore, and general cargo commodities sensitive to season extension. Throughout this report the total forecasts always refer to the sum of these four categories (grain, coal, iron ore, general cargo).

A shipper's choice of a transportation route is a highly specific decision which may include many sub-decisions with respect to the numerous aspects of the movement of commodities from one point to another. Even though a commodity may travel through multiple phases between origin and destination, the shipper's routing decisions are based on true origin to true destination. Total costs and services are considered in the decision. The choice of the mode of transportation is not made in isolation, but is made as a package.

The region that serves as an economic base which can potentially provide the GL/SLS with commodities for transportation is referred to as the Great Lakes hinterland. Corresponding market areas were similarly defined for Canada. For the purposes of this analysis the traffic movements were separated into two categories: bulk commodities and general cargo.

Bulk Commodity Projection Methodology

The general allocation procedure used to estimate the true origins and destinations of bulk movements and to identify potential GL/SLS movements that do not currently exist relied upon the following data:

a. waterborne movements via GL/SLS by commodity;

b. Department of Transportation (DOT) 1% Waybill Sample of railroad movements;

c. Bureau of the Census Foreign Trade Statistics showing U.S. waterborne commerce by port, customs district, and world trade area; and

d. Canadian shipping statistics.

The projections developed for bulk commodities were based, in a large part, on existing published projections of economic activity. The following is a discussion of the assumptions for the projections of the major bulk commodities involved in this analysis.

Iron Ore Projections

Iron ore is the single largest volume commodity currently moving on the GL/SLS system. The traditional pattern of iron ore movements is from sources in the Lake Superior district to steel mills on Lake Michigan, Lake Huron, and Lake Erie. These movement projections generally parallel the projected growth rates of the steel industry in the destination regions with the following assumptions:

a. the iron content of pelletized iron ore has nearly reached practical levels and thus growth in tonnage moved should keep pace with industry growth;

b. the projected mix of furnace type in the steel industry will reverse the current trend toward more scrap usage; and

c. the ratio of iron content to pig iron will remain at current levels.

The result of these basic assumptions is that future iron ore movements are expected to grow at the same rate as raw steel production in the demand region.

Coal Projections

Coal is the second largest commodity moving on the system. Over the past five years the volume of coal moved has remained relatively stable, however, major growth is expected in the future as the new Duluth/Superior coal transloading facility becomes operational. This facility is being constructed to transport coal from Montana (Western coal) to Detroit Edison power plants on Lake St. Clair.

The assumptions concerning the outcome of Federal guidelines and individual utility decision may greatly influence not only the volume but also the pattern of the potential coal movements. Only those

movements currently planned (whether planned for the GL/SLS system or not) were included in the forecast potential. In addition, the projections reflect the following assumptions:

a. few, if any, existing utilities would be converted to low sulfur Western coal due to high conversion costs;

b. only new facilities that have announced plans for use of Western coal would be included in the forecast;

c. stack gas scrubbers would be economically efficient and available by 1990;

d. current emission standards will remain unchanged throughout the forecast period;

e. variances to burn high sulfur coal will be extended until stack gas scrubbing technology becomes available;

f. Canada will adopt emission standards that will not preclude usage of U.S. Eastern coals;

g. the development of nuclear power generation facilities will be delayed and retarded by environmental, safety, and economic factors; and,

h. environmental concerns regarding strip mining will not restrict the growth of coal mine development in the West.

These projections were made by contacting the individual utilities and steel companies currently moving coal or planning to move it. This approach was feasible due to the relatively small number of users currently or potentially receiving coal via the GL/SLS system.

Grain and Agricultural Products Projections

Agriculture products include corn, wheat, soybeans, barley and rye, other cash grains, and other farm products and are listed in approximately their relative order of volume moved on the GL/SLS system. Since most grain movements are for export, projections of potential movements were based on U.S. Department of Agriculture (USDA) export projections. Domestic movements of grain were assumed to grow at the rate of Office Bureau of Economics-Economic Research Service (OBERS) earnings projections for the food industry in the demand region. The projections incorporate the following major export related assumptions:

a. the U.S. will remain as the leading food supplier to the world;

b. due to population growth and consumption trends, most future exports will be destined for less developed countries;

c. Europe's trend toward grain self-sufficiency will continue, however, certain U.S. grains will still be imported for blending purposes;

d. the U.S. will regularly export grain to the Soviet Union, but in a more stable pattern; and,

e. the U.S. will remain as Japan's most important supplier of grain.

General Cargo Projection Methodology

The general cargo forecasts were developed from projections of U.S. and foreign Gross National Product (GNP).* The GNP projections

*Gross National Product is the total final market value of all goods and services produced by an economy in one year.

were used to measure the growth in real income. In addition, a projection was constructed of total U.S. trade by commodity and trade area. A relationship between the trade and income projections is established and the growth indicative of this relationship is then used to project the growth of the general cargo commodities potential to GL/SLS.

No projections of U.S. domestic general cargo movements were made. These movements were not included because they are principally cross-lake rail ferry movements (a service that is expected to be discontinued), and because alternative route capabilities for the movement of domestic general cargo effectively preclude GL/SLS participation.

Once the total trade projections were made for general cargo, the traffic was allocated back to true origin and destination. Thus, it was possible to calculate the share of the total U.S. trade which originated or was destined to each state and to calculate the share from each state that went through the GL/SLS system. Projections of the total potential of general cargo movements are presented in Table 2.

High and Low Projections

Three levels of projections (low, medium, and high) for bulk commodities and general cargo were constructed for this study. The medium level corresponds to a "most likely" projection. The purpose of these additional projections was to permit sensitivity analyses, to adjust forecast levels to account for changes in assumptions, and to include a range in the forecasts.

TABLE 2

TOTAL REGIONAL DEMAND

Forecasted Movements

(Millions of Short Tons)

Commodity	1980	1990	2000	2010	2020	2030	2040
Grain	98.1	131.5	186.7	253.2	317.2	364.1	404.0
Coal	85.9	110.9	133.0	159.3	181.5	207.1	237.9
Iron Ore	110.0	132.6	158.3	189.2	221.3	259.7	304.9
General Cargo	38.2	54.6	78.3	112.9	163.8	239.0	350.3
Total	332.2	429.6	556.3	714.6	883.8	1,069.9	1,297.1

Summary

The potential movements for all bulk commodities and general cargo are summarized in Table 2. The potential traffic presented in Table 2 does not represent all bulk commodity groups that move within the region, but only those that will be affected by the season extension to the navigation on GL/SLS. The general cargo category encompasses nearly all general cargo commodity groups. The growth for the total of these commodities for the 1990-2040 study period, an increase from 429.6 to 1297.1 million short tons in 2040, reflects an annual growth rate of 2.3 percent.

Table 2A displays in percentages that portion of total regional demand among commodities listed which is expected to be moved on the Great Lakes/St. Lawrence Seaway. Projections of harbor traffic shares are made based in the first instance on service and rate factors alone, and secondly considering the capacity constraints in the navigation system.

INTERMODAL TRAFFIC SPLIT

The intermodal traffic split makes the decisions as to what will be the specific commodity traffic flows for the future of the GL/SLS. The relationship between the informational factors and the traffic split is visually presented by the flow diagram.

A prerequisite for the decision making process is a projection of future levels of commodity traffic that may potentially be routed through the Great Lakes - if the GL/SLS were to receive a 100% market share of commodity movements. Once these projections, or forecasts, are known, then the shipper must decide how the cargo should be delivered. The shipper makes a decision with respect to three alternative modes of transportation: by truck, railroad, or vessel.

There are two formal components to the shipper's decision criteria. These are service factors and rate factors. These factors may be considered to be internal constraints. The shipper, in the light of these constraints, makes the decision as to how the cargo will be sent. This is the basis of the traffic split.

TABLE 2A

Percentage Share of Regional Demand for Water Susceptible Flows

Commodity	1980	1990	2000	2020	2040
Total Regional Demand					
Grain	100.0	100.0	100.0	100.0	100.0
Coal	100.0	100.0	100.0	100.0	100.0
Iron Ore	100.0	100.0	100.0	100.0	100.0
General Cargo	100.0	100.0	100.0	100.0	100.0
Total	100.0	100.0	100.0	100.0	100.0
Intermodal Flows Allocated to GL/SLS on Service & Rate Factors Unconstrained by Lock Capacity					
Grain	35.8	22.9	27.5	21.4	19.8
Coal	43.8	48.6	48.7	46.7	41.8
Iron Ore	87.2	90.6	91.9	91.9	92.0
General Cargo	20.2	21.1	22.2	22.6	23.0
Total	53.1	53.1	50.1	44.5	41.7
Capacity Constrained GL/SLS Season Extension Harbor Traffic					
Grain	15.7	13.0	9.9	6.1	4.9
Coal	43.7	47.0	46.0	40.2	33.9
Iron Ore	80.3	81.7	80.4	66.0	50.0
General Cargo	17.5	14.7	11.1	5.3	2.5
Total	44.5	43.2	38.7	27.9	20.1

The process begins by testing the potential traffic and identifying that cargo which will not use a GL/SLS routing due to service factors. Of the remaining traffic, the process conducts tests to determine if the GL/SLS is cost competitive. The GL/SLS market share for all commodities is currently about 45 percent and this share will deteriorate without capacity improvement to the GL/SLS system.

There is one final check that must be considered. There are constraints that exist with respect to the GL/SLS. A particular constraint for the GL/SLS is the capacity of a lock system. A lock has the potential of preventing the projected traffic, in simply a physical sense, from passing through the GL/SLS. Subject to these external constraints, the result of this approach is a projection of commodity and vessel traffic which will move as a result of the navigation improvements.

In summary, the modal split analysis permits determination of the GL/SLS traffic volume variations attributable to various service and cost-related changes. In all cases, these changes are evaluated relative to alternative route transport options available to the shipper.

SERVICE AND INSTITUTIONAL FACTORS

The service factors represent, in many cases, the more qualitative and subjective elements (in contrast to cost factors) which influence the shipper decision making process. This service component is composed of two basic elements: Institutional constraints and service factors.

Institutional Constraints

Institutional constraints are such that they tend to predetermine routes for shippers. Examples of these types of constraints include facilities and handling capabilities, fleet ownership, supply

contracts, certain corporate policies and regulatory considerations. In the short-run, many of these constraints may be considered fixed. However, over the sixty-year period considered by this analysis, the majority may be treated as variable. The effect of the application of these constraints on a given origin/destination commodity movement is to reserve a portion of the total movement for that mode of transportation and route which is favored by the constraint.

Service Factors

Service-related factors often predispose shippers to route commodities in a given manner. However, unlike institutional constraints, service factors are not long-term in nature. Service factors are, in many cases, intrinsic to a given route, variable in the short-run, and controlled directly by organizations external to the shipper (e.g., steamship companies, port authorities, etc.). Examples of service factors include service continuity (year-round availability), transit time, sailing frequency, schedule reliability, loss and damage experience, containerization, land feeder service, shipping infrastructure, and transloading efficiency.

The effect of the application of service factors is to identify a portion of the total commodity movement for which GL/SLS cannot effectively compete. Thus, service reserves are developed for the GL/SLS alternate route. Therefore, the GL/SLS routes in these cases are, in a service sense, considered equal to or less attractive than the alternate routes.

The extent to which shippers in their decision making process are sensitive to service factors varies by commodity and commodity groups. These sensitivities were determined and developed through a shipper preference survey. This survey assessed the relative importance of various cost and service-related factors vis-a-vis the shipper's commodity routing decisions.

Although the survey indicated that there were many factors considered by shippers in their decision making process, the following criteria appeared to be most common and were subsequently incorporated into the analysis:

a. service continuity;

b. shipment time, including combined effects of sailing frequency and transit time;

c. service reliability (schedule and handling); and,

d. degree of containerization.

Application of Service Factors

There are two aspects to the application of these qualitative service factors to the traffic analysis. The first aspect is a decision the traffic analysis technique must make regarding the degree of the level of improvement of a specific alternative or improvement (i.e., length of navigation season, degree of containerization, etc.). In the context of the analysis there are four such decisions (as discussed in the above paragraph) that the analysis must make.

Yet, the shipper when making the decisions does not weigh all these decisions equally. Some of the decisions are more important to the shipper than others. It is the purpose of the analysis to reflect "real world" conditions of the shipper. The second aspect of the application of service factors to the analysis is to reflect the differences of the weights of the decisions. This is accomplished by

applying percentage weights to the above decision alternatives. The result is weighted service criteria being incorporated into the traffic analysis.

Summary

The findings of the shipper preference survey resulted in the development of shipper reaction profiles. These profiles are the weighted quantitative representation of the value shippers place on various service factors in determining commodity transportation routings. Because these qualitative and subjective elements have been quantified, the snipper's route preferences can be incorporated into the traffic analysis.

TRANSPCRTATION RATES

Transportation rates are one of the principal data inputs to the GL/SLS traffic analysis. This data base contains all the freight rate data required to allocate rate sensitive traffic to either GL/SLS or a competitive route. This data base is referred to as a rate file.

Structure of the Rate File

The commodity flow forecasts (discussed in "Total Regional Transportaticn Demand" above) are expressed in terms of commodity by geographic area. In order for the transportation rates to be compatible with the traffic forecasts, the rates must also be expressed in the same terms. Consequently, a potential flow is defined by its origin, destination, and by commodity. In the GL/SLS study there are 6,852 such combinations with cargo. In addition, each combination may require as many as six cost elements, including three freight rates. This produces over 30,000 component rates. A

sample of approximately 2,000 rates was compiled from which competitive rate information was determined for each origin, destination, commodity combination that may move along the GL/SLS.

The basic commodity unit in the analysis is a commodity family. Every commodity potentially moving within the GL/SLS has been classified into one of 37 families. Of these, 22 are bulk cargo families, which are homogeneous, and the remaining 15 are general cargo families, which are all highly diversified.

The general cargo U.S. origins and destinations are defined in terms of 19 states in the GL/SLS region. The bulk cargo U.S. origins and destinations are identified by 90 primary areas and 99 secondary areas. Canadian origins and destinations are defined by eleven areas which border the GL/SLS and foreign trade is defined in terms of nineteen trade regions.

Methodology

There are two phases to providing the rates required to complete the rate file. The first phase is the development of a process that will produce any land or water freight rate based on the origin and destination points of the movement and the characteristics of the commodity. Rates for a commodity are provided for all modes of transportation normally used to move that commodity. An important factor influencing the level of freight rates is shipment size. Normally, per unit rates decrease as minimum lot sizes increase.

The first phase produced a rate for a specific commodity over a specific route. The second phase of the method develops techniques to use the rate of the first phase to produce through rates compatible with geographic characteristics and the current cost differentials for competitive routes. The second phase rates,

developed for general cargo, are weighted average rates which reflect the least cost through rate for a Great Lakes and for a competitive route. The weights were calculated for general cargo because of the diversity of these commodity families. Weighted rates were not calculated for bulk commodities because the bulk commodity families and interior origins and destinations are relatively homogeneous.

Several factors influenced the approach for developing the above transportation rates. These considerations are:

a. freight rates are quoted for point-to-point movements of specific commodities, and are not directly related to the geographic areas and heterogeneous commodity families of the rate file;

b. the large number of freight rates required (more than 30,000 overland and waterborne rates) rendered an individual fill-in approach infeasible; and

c. satisfying the rate requirements of the rate file required only the establishment of relative rate advantages for competitive routes and not necessarily an extensive file of absolute rates.

The approach taken in this study reflects a compromise between the absolute accuracy of rate quotations and the extensive geographic and commodity diversification of the rate file.

Validation

The objective of the study was to provide a measure of the relative cost advantage or disadvantage of the GL/SLS system compared to an alternative routing. The most critical element of the method with respect to accuracy is the development of a rate file based on a statistical sample of actual freight rates. A sample of

approximately 2000 actual rates was used in the compilation of the rate file. The validation tests produced the following results:

a. calculated rates were usually accurate to within 20% of actual rates and consequently care should be exercised in calculating individual absolute rate levels;

b. the equations did not produce a rate bias in favor of either a GL/SLS or competitive route; and

c. using the above method to allocate cargo to competitive routes, significant inaccuracies in absolute calculated rates (37%) led to a corresponding "error" in tonnage allocation of only 4%.

These tests demonstrated that the rate levels reflected by the above method, on the whole, are highly representative of the relative cost advantages or disadvantages of the GL/SLS system.

Conclusions

The above discussion of method indicated the wide commodity and geographic diversity of lake potential commerce. The following are observations and conclusions related to general trends which were noted during the study.

a. Ocean rates and overland rates are the significant factors which explain the freight rates calculated by the above approach. Ocean rates and their corresponding trade routes are characterized by distinctive rate structure which reflect a unique combination of market factors. In such cases distance may be considered constant while the major elements which determine rate levels are stowage factor and value per ton. Unlike ocean rates, the most significant explanatory factor for overland rates is distance. To a lesser

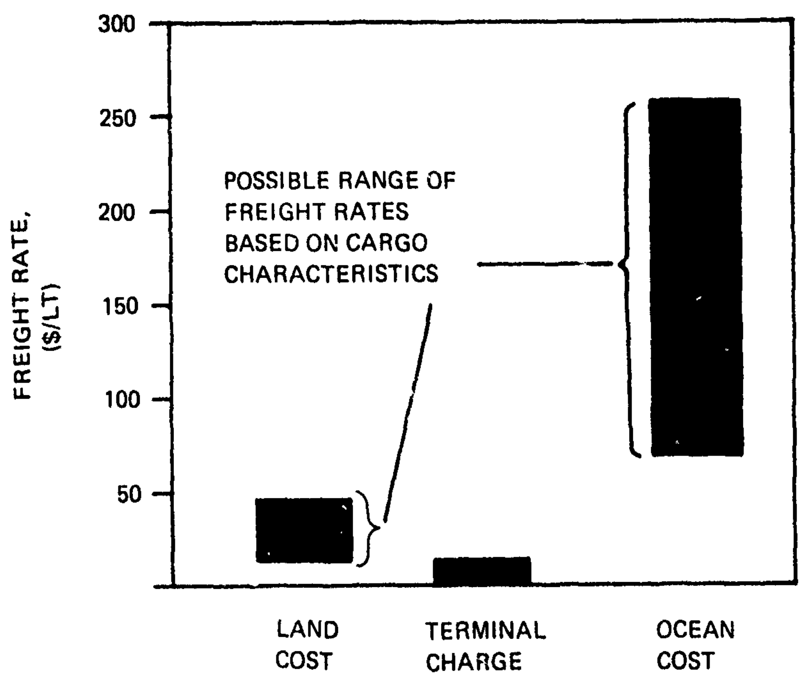
extent stowage factor and value per ton are positively correlated with rate.

b. A complete overseas through rate is normally comprised of three rate components, an overland cost, a terminal charge, and an ocean cost. Typical ranges for these components are displayed in Figure 3. As indicated in the diagram, the single rate component which has the largest impact on the cost advantage of a given route is the ocean cost. For domestic movements, a Great Lakes Route, in most cases, involves an overland haul to a lake port and a waterborne haul. A competitive route involves a direct overland haul from origin to destination. The rates collected during the study indicate that on a per-mile basis most bulk commodities move at a lower rate by water than by land. This difference is illustrated in Table 3.

c. The cost advantage of a Great Lakes or alternative route depends on competitive through rates consisting of overland transport cost, terminal port charges and ocean cost. The level of each of these cost components is a function of commodity characteristics, and the location of the origin and destination of the movement in question. The data in Table 4 presents a comparison of rates for selected commodities which are significant in movements involving the Great Lakes Region. Rates for the lowest cost ocean port route and Great Lakes route are provided.

The rates for selected commodities presented in Table 4 are provided solely for illustrative purposes. Yet, these rates are actual movements used in the analysis. For example, coal, mined in the Billings, Montana area will eventually move to Detroit. To ship this by rail would cost \$1.06/cwt (\$21.20/ton). An alternative provided by season extension is to move the coal by rail from Billings to Duluth and by vessel to Detroit. The total cost of this route is \$.67/cwt (\$13.40/ton). The savings of moving the coal over the Great Lakes as opposed to shipment by rail is \$.39/cwt or \$7.80/ton.

FIGURE 3
Relative Rate Components



TRADE: U.S. (ALL COASTAL RANGES) TO NORTHERN EUROPE
MODE: CONTAINERIZED
COMMODITY CHARACTERISTICS:

- STOWAGE FACTOR (0.6-3.0)
- VALUE PER TON ($500-$3,500)

OVERLAND DISTANCE (0-600 MI.)

TABLE 3

Representative Bulk Rates

(All rates in cents per 100 miles)
(Rail rates are single carload unless otherwise noted)

Commodity	Mode: Rail	Mode: Water
Coal	5**	1.5-2.3
Sand and Gravel	18*	4.3*
Fuels	3.1+*	1.6*

*Distance 600 miles
**Multiple car rates
+Pipeline

SOURCE: Booz-Allen & Hamilton, Inc.

Summary

A summary analysis of the rates collected during this study has indicated that the data contained in Table 4 are representative of the competitive positions of the Great Lakes for overseas cargo. In general the Great Lakes system appears to offer through rates for many commodities which are equal to or lower than rates through competitive ocean ports.

This conclusion should be interpreted with the following qualifications. Rates were collected during the early part of the 1977 shipping season and reflect conditions at that time in a dynamic market. In particular, the rates reflect the current container service in the Great Lakes which continues to have a major impact on prevailing freight rates. Finally, while generalizations concerning the rate attributes of the Great Lakes system may be made, rates for specific commodity movements must be determined on an individual basis.

TABLE 4

COMPARISON OF THROUGH RATES FOR SELECTED COMMODITIES AND ROUTINGS: YEAR 2000
(Rates in cents/cwt.)

			Great Lakes Ports				Alternate Ports				
Commodity	Origin	Destination	Land Haul*	Terminal	Ocean Haul	Total Cost	Land Haul*	Terminal	Ocean Cost	Total Cost	Cost Advantage To Great Lakes
Corn	Chicago	St. Lawrence Seaway	24 T	34	35	93	145 T	0	0	145	52
	Sioux Falls	Eastern Europe	43 R	12	82	137	96 R	18	48	162	25
Wheat	Grand Forks	Japan	49 T	12	131	192	133 R	11	72	216	24
Soybeans	Fort Wayne	Northern Europe	25 T	10	80	115	79 R	12	47	138	23
Coal	Billings	Detroit	42 R	8	17	67	106 R	0	0	106	39
	Cheyenne	Buffalo	47 R	8	17	72	106 R	0	0	106	34
Iron Ore	Duluth	Chicago	15 R	5	20	40	55 R	0	0	55	15
	Duluth	Pittsburgh	15 R	28	20	68	110 R	0	0	110	42
Iron and Steel	Pennsylvania	Northern Europe	55 R	15	345	415	79 R	27	334	440	25
	Indiana	Mediterranean Europe	47 R	19	351	417	148 R	14	283	445	28

*T = Truck Haul R = Rail Haul

Table 5 presents the forecasts of the rate and service sensitive commodity movements along the GL/SLS. The forecasts of this table reflect the impact of the transportation rates and service factors upon the potential commodity movements available to the GL/SLS region.

CAPACITY ANALYSIS

The capacity of a navigation system is determined by its slowest processing element(s). For the GL/SLS these elements are the locks in its three locking systems (the Soo, Welland, and St. Lawrence Seaway).

System Description

The Soo Locks are located at Sault Ste. Marie, Michigan, in the St. Marys Falls Canal. They connect Lake Superior with the lower lakes. Each of the Soo's four parallel locks (MacArthur, Poe, Davis, and Sabin) has its own pier, which can accommodate two or three ships in a queue. The fifth lock in the Soo system, on the Canadian side of the St. Marys River, is not included in this analysis because of its small size and primary usage by small passenger or pleasure craft. The dimensions of the four parallel locks are listed in the first part of Table 6. With the Navigation Season Extension Program, the Soo Locks operate 10 to 12 months per year, ceasing operations when ships stop operating. Normal operation prior to the Program was nine months per year, from April to December.

The MacArthur Lock currently handles most of the downbound loaded ships with overall lengths of 730 feet. The Poe Lock processes "1000 footers" and all vessels which the MacArthur cannot service. Normally either the Sabin or Davis (both identical) handles most of the ballasted upbound ships with lengths up to 826 feet.

TABLE 5

WATERBORNE INTERMODAL TRAFFIC SHARE

	Forecasted Movements (Millions of Short Tons)								
COMMODITY	1980	1987	1990	1992	1993	1995	2000	2020	2040
Grain	35.1	40.0	42.7	45.0	45.7	47.3	51.3	67.8	80.1
Coal	37.6	48.9	53.9	56.2	57.3	59.4	64.8	84.8	99.5
Iron Ore	95.9	112.7	120.2	125.6	128.1	133.0	145.4	203.4	280.5
General Cargo	7.7	10.1	11.5	13.1	13.7	14.8	17.4	37.1	80.5
Total	176.3	211.7	228.3	239.9	244.8	254.5	278.9	393.1	540.6

TABLE 6

LOCK DIMENSIONS

St. Marys System (U.S.)

Principal Features	MacArthur	Sabin	Davis	Poe	Canadian
Width, feet	80	80	80	110	59
Length between mitre sills, feet	800	1350	1350	1200	900
Depth on upper mitre sill, feet	31	24.3	24.3	32	16.8
Depth on lower mitre sill, feet	31	23.1	23.1	32	16.8
Lift, feet	22	22	22	22	22

St. Lawrence System (U.S. and Canadian)
(Each Lock)

Length, breast wall to gate fender . . . . . 766 feet
(ships may not exceed 730 feet in overall length or 75.5 feet in maximum breadth)

Width . . . . 80 feet

Depth over sills . . . . 30 feet

Lock Lifts
- St. Lambert . . . . 13 to 20 feet
- Cote Ste. Catherine . . . . 33 to 35 feet
- Lower Beauharnois . . . . 38 to 42 feet
- Upper Beauharnois . . . . 36 to 40 feet
- Snell . . . . 45 to 49 feet
- Eisenhower . . . . 38 to 42 feet
- Iroquois . . . . 0.5 to 6 feet

Welland System (Canadian)
(Each Lock)

Length, breast wall to gate fender . . . . . 766 feet
(ships may not exceed 730 feet in overall length or 75.5 feet in maximum breadth)

Width . . . . 80 feet

Depth over sills . . . . 30 feet

Lock Lifts . . . . 40.5 feet (Average)

The Weiland Canal System, approximately 27 miles long, parallels the Niagara River and connects Lake Erie and Lake Ontario. The dimensions of the eight-in-line locks in the system are given in the last part of Table 6. Locks 1, 2, 3, and 7 are single lift locks, while 4, 5, and 6 have two parallel (twinned) sets of lift locks. Lock 8 is primarily a guard lock. The Welland System normally operates from April through December. Lock 7 is considered to be the most constraining lock because of its long lock cycle time and proximity to other flight locks. Lift bridges for land traffic and narrow channels are also bottlenecks.

The St. Lawrence Seaway System extends approximately 190 miles from Lake Ontario to St. Lambert Lock in Montreal. The System was created by channel excavation (to a 27 foot depth) and the construction of seven locks, two of which are operated by the United States, 5 by Canada. Their dimensions are also given in Table 6. The Beauharnois Locks are considered to be the most constraining because of the lack of vessel waiting areas between the locks and the large number of pleasure craft lockage through the locks.

Capacity Estimation Process

As the annual tonnage on the GL/SLS system increases, the demand for service (tonnage to be transported) at these three locking systems will increase, and it is anticipated that vessels will begin to experience long waiting times and long vessel queues as capacity is approached.

A queuing model, which analyzes steady-state lock operations and vessel-lock interaction, was utilized to determine if, or when in time, the Soo, Welland, and Seaway Lock Systems could be expected to reach capacity as a function of:

a. cargo traffic projections;

b. vessel fleet projections;

c. vessel operating characteristics and locking times;

d. lock operating characteristics;

e. length of navigation season;

f. available operating time (weather delays, lock malfunction delays, daylight-only navigation);

g. pleasure craft and non-commercial vessel locking requirements; and,

h. winter vessel and lock operating procedures.

For a given set of the above data and a specific year, the following output was generated for 14 separate time periods (10 months plus early and late April, and early and late December):

a. cargo transported by commodity and direction;

b. vessel operating fleet;

c. yearly vessel transit demand by vessel class;

d. commodity and direction;

e. daily vessel transit demand by vessel class and direction;

f. lock cycle time by direction (mean and standard deviation);

g. average vessel waiting time by direction;

h. average vessel queue length by direction;

i. lock utilization; and,

j. vessel delay costs.

Using this output, an independent decision was made as to whether or not a capacity condition occurred based on a prescribed capacity criteria such as: average vessel waiting time, average vessel queue length, and lock utilization.

Basic Assumptions

The following assumptions were made in developing the output.

Vessels

a. All ships in the fleet are represented by specific ship classes.

b. All ships attempt to maintain their maximum capable speed at all times except where speed limits exist.

c. A ship's maximum speed capability is determined by analyzing the ship's thrust capability versus its resistance characteristics in open water and ice.

d. No accidents involving ships are assumed to occur in the system and no time delays due to accidents are considered.

e. All lakers are assumed to lay-up at the end of the navigation season, while all ocean-going ships are assumed to operate elsewhere.

f. All ships are treated on an equal basis.

g. All ships operate only during the daylight hours in areas where nighttime navigation is prohibited, such as the Welland Canal and St. Lawrence Seaway.

h. All ships are assumed to carry a full cargo.

i. All ships carry only one cargo at a time.

j. Lakers are phased-out or retired from the fleet based on a 75 year useful life.

k. When additional ships are needed because the cargo demand is greater than the fleet transporting capacity, largest ships are built first.

l. When the cargo demand is less than the fleet transporting capacity, the smallest ships are deleted first.

Locks

a. Each lock can be described as a single-server with a simple waiting line queue.

b. Vessels are processed on a first come-first served basis.

c. Lock Service time distribution is characterized by its mean and standard deviation.

d. Vessel arrival rate follows a Poisson distribution.

e. Vessels are locked through in a manner which minimizes the lock's utilization (maximizes its capacity). If queues exist on both sides of the lock, the lock alternates in processing upbound and

downbound vessels. If a queue exists on one side of the lock and the time of arrival of a vessel at the other side of the lock is less than the turnback time of the lock, the lock waits to process the arriving vessel. Otherwise, it turns back to process the next vessel in the queue.

f. Only one vessel at a time is processed by a lock.

g. The capacity of each lock system is determined by the constraining lock and the distance between locks does not prohibit the Poisson distribution of vessel arrivals.

h. At the Soo, vessels arriving are sorted by their use of the lock and form independent queues for each lock. In sorting vessels to each lock, vessels are assigned in a manner which minimizes the system's utilization (maximizes its capacity) within prescribed vessel-lock constraints. As queues form, vessels are dispatched to the waiting space provided at each lock in such a manner that no other vessel is blocked from entering an idle lock.

Cargo

a. The total annual tonnage for ore and coal, which are considered to be stockpiled commodities, is assumed to be distributed based on the fleet cargo transiting capability and, as a result, "normal season tonnage" can be shifted to the extended navigation season period.

b. Grain and general cargo are not considered stockpiled commodities and their "normal season tonnage" can not be shifted to the extended navigation season period. Extended navigation season grain and general cargo tonnages are assumed to be evenly distributed during the extended navigation season.

c. Stone and other bulk are assumed to be independent of season extension with their entire tonnage demand transported during the normal season.

Methodology of Lock Operation Analysis

Six steps were used to develop the output from which capacity estimates were made.

1. Fleet Determination

The required vessel fleet mix for a given lock system needed to carry the projected cargo demand was forecast by commodity and vessel class. This was accomplished by first determining the number of round-trips each vessel class and commodity combination can make during the entire navigation season for a given set of trade route and vessel data. Then the remaining fleet was determined by adding or deleting ships as necessary until the vessel capacity equals the cargo demand.

2. Estimation of Vessel Transit Forecast Demand

From the vessel fleet mix and annual cargo demand projections the vessel arrivals at a lock system were forecast by vessel class, direction, and commodity. Loaded transits and cargo distribution were calculated for each time period, given set of cargo tonnage demand, and vessel characteristics. A ballast transit distribution for each time period was calculated based on vessel utilization. It was then applied to get loaded and ballast transits.

3. Estimation of Ships Dispatched at the Soo

To insure maximum lock capacity, vessels are dispatched at the Soo assuming: loaded class 4 and ballasted class 4, 5, 6, 7 and 8

vessels are assigned to the Sabin and Davis Locks; loaded class 5, 6 and 7 vessels are assigned to either Poe or MacArthur Locks; class 9, 10, and 11 vessels and loaded class 8 vessels are assigned to the Poe Lock.

4. Estimation of Lock Cycle Time

Mean upbound and downbound lock cycle times and their variances were calculated as a function of the transit forecast of vessels by class and direction, lock turn back characteristics and traffic levels for each of the 14 time periods.

5. Determination of Average Vessel Waiting Time

Using the Pollaczek-Khentchine formula, vessel waiting time, average queue length, and lock utilization were estimated based on vessel transit forecast, mean lock cycle time, available lock operating time, lock malfunction, ice and weather delays, and non-commercial lockages.

6. Estimation of Delay Costs

Delay costs were calculated by multiplying the average queue waiting time per vessel by the vessel cost per hour. The results of this procedure produced findings of changing distribution of vessel arrivals by vessel class and the capacity levels for the three lock systems. The above analysis was conducted with a ship utilization rate of 70 percent and the results were compared to actual 1976 data.

Vessel Distribution

Table 7 illustrates the observed and projected trends toward larger vessels in the Great Lakes/St. Lawrence Seaway. Historically, the trend towards larger merchant vessels has taken place in spite of a number of difficult problems in the areas of design and management associated with larger ships. The underlying benefit responsible for this trend towards larger merchant vessels, can be broadly identified as the "economic advantages of scale." Larger sizes, generally in terms of deadweight, cost less to build and operate, per ton of cargo capacity. Potential revenue increases proportionately with deadweight, while the various components of cost, both capital and operating, increase less than directly proportional. The validity of these statements is indicated in the history presented in Table 7. The specific year snap shots display a gradual but persistent shift to a Great Lakes fleet containing an ever greater percentage of vessels in the larger sizes.

However, there are limits to continued growth in the size of Great Lakes vessels because it is no longer possible to increase all vessel dimensions in historical proportions. This means, for example, without additional channel depth the lengthening of vessels beyond 1100 feet may not be economically attractive to potential owners.

Lock Capacity Levels

The approach to determining the capacity tonnage for each of the three lock systems began by taking annual tonnage demand from projections of intermodal traffic split for each of four season lengths from 1980 to 2040. Annual tonnages were then distributed by month for each navigation season in accordance with appropriate shipping procedures for each commodity. With stockpiled commodities such as ore and coal, there was some shifting of "normal season"

TABLE 7

VESSEL FLEET MIX VARIATION WITH TIME FOR THE SOO LOCKS AND THE ST. LAWRENCE SEAWAY

		NUMBER OF VESSELS					
		SOO LOCKS			ST. LAWRENCE SEAWAY		
CLASS	VESSEL LENGTH (Feet)	1976	1990	2000	1976	1990	2000
4	550-599	6.0	3.0	3.0	19.0	13.0	11.0
5	600-649	35.0	34.0	27.0	12.0	9.0	8.0
6	650-699	22.0	42.0	51.0	41.0	82.0	108.0
7	700-730	26.0	45.0	51.0	15.0	26.0	34.0
8	731-849	7.0	7.0	9.0			
9	850-949	1.0	1.0	1.0			
10	590-1000	2.0	17.0	27.0			
11	1100-1199	0.0	0.0	0.0			
TOTALS		99.0	149.0	169.0	87.0	130.0	161.0

tonnage to extended seasons, thereby reducing required loaded transits and the probability of capacity conditions occuring.

Table 8 presents the capacity tonnage and the year that capacity is reached for the three GL/SLS lock systems.

Soo Lock System: Capacity conditions at the Soo were calculated by inputting the projected annual tonnage demand and allowing the vessel fleet requirements to be updated within the analysis (in the fleet forecast section). Lock capacity was defined as mean lock utilization, mean vessel waiting time, and mean vessel queue length equal to 87.5 percent, 4 hours, and 3 ships, respectively, for an extended period of time. This is a "typical" capacity definition, as capacity conditions could exist when the mean lock utilization, waiting time, and queue length are above or below the figures given above. Capacity conditions at the Soo System were estimated to occur in 1990 at 163,800,000 short tons with a nine month navigation season; in 2005 at 221,400,000 short tons with a twelve month season (See Table 9).

Welland Canal Lock System: The same analysis was used to estimate capacity at the Welland and St. Lawrence Seaway Systems. In addition to comparing actual data to results of the analysis using 1976 traffic data for daily transits and distribution of vessel arrivals, the ratio of loaded vessel transits to total vessel transits was also compared. This validation was made using a ship utilization rate of 70 percent. The results for the first two categories were acceptable, while the ratio of loaded to total vessel transits was as follows:

	Actual	Computed
Upbound	63%	49%
Downbound	90%	84%

TABLE 8
CAPACITY TONNAGE FOR
LOCK OPERATION OF DAYLIGHT ONLY AND 24-HOUR NAVIGATION
(1,000,000 Short Tons)

Extension To:		SOO		WELLAND				ST. LAWRENCE			
		24-Hour		Daylight		24-Hour		Daylight		24-Hour	
Upper Lakes	St. Lawrence	Tons	Year Capacity Occurs	Tons	Year Capacity Occurs	Tons	Year Capacity Occurs	Tons	Year Capacity Occurs	Tons	Year Capacity Occurs
12 mo.	11 mo.	221.4	2005+	86.9	1980	93.7	1985+	106.4	2000	109.4	2000+
12 mo.	10 mo.	221.4	2005+	84.5	1980	91.1	1985+	103.6	2000+	106.7	2000+
12 mo.	9 mo.	221.4	2005+	80.9	1980	87.2	1985	100.6	2000+	102.9	2000

Capacity at the Welland is expected to be reached before implementation of 9 month (1990), 10 month (1995), and 11 month (2000) navigation in the winter on the Welland Canal. Capacities shown are for the complete implementation of each of the three time phased plans shown in the table.

TABLE 9
SUMMARY OF PROJECTED ANNUAL TONNAGE*
FOR SOO LOCK SYSTEM
(THOUSANDS OF SHORT TONS)

NAV. SEASON	DIRECTION	1976**	1980	1987	1990	1991	1992	1995	2000	2020	2040
1 Apr - 31 Dec (9 months)	Downbd	83210	112800	137298	147886	150765	153701	162480	177125	242854	316547
	Upbd	9663	12360	14625	15604	15983	16381	17585	19570	27118	35521
	Total	92873	125160	151923	163490	166748	170082	180065	196695	269972	352068
1 Apr - 31 Jan (10 months)	Downbd	83210	113618	138259	149591	152520	155484	164380	179218	245871	320583
	Upbd	9663	12474	14757	15741	16135	16533	17748	19753	27402	35920
	Total	92873	126092	153016	165332	168655	172017	182128	198971	273273	356503
1 Apr - 28 Feb (11 months)	Downbd	83210	113618	138721	150078	153534	157076	166074	181075	248522	324112
	Upbd	9663	12474	14804	15794	16218	16618	17847	19858	27565	36143
	Total	92873	126092	153525	165872	169752	173694	183921	200933	276087	360255
1 Apr - 31 Mar (All-year)	Downbd	83210	113618	138741	150097	153591	157148	166143	181143	248625	324255
	Upbd	9663	12474	14815	15807	16231	16632	17862	19878	27592	36184
	Total	92873	126092	153556	165904	169822	173780	184005	201021	276217	360439

Capacity: 221.4 million tons in 2005

*Includes all commodity groups
**Actual Tonnage

The discrepancy in ratios results from the fact that many vessels transiting the Welland carry partial (50 to 75 percent full) loads, while the analysis permits only full or ballast transits. This discrepancy was not adjusted in the validation process because it was assumed that, as the Welland approaches capacity, vessels will operate closer to their carrying capacity than they currently are.

Capacity conditions at the Welland were calculated by inputting the projected annual tonnage demand and allowing the vessel fleet requirements to be updated within the analysis (in the fleet forecast section). Because of the large projected increase in annual tonnage at the Welland in the next few years, capacity conditions are expected to occur before 1990 at 91,100,000 short tons. Because 60 percent of this traffic is comprised of grain, other bulk, and general cargo commodities that are not easily shifted from "normal season" to an extended season, season extension generates only a small shift as to when capacity occurs. (See Table 10.)

St. Lawrence Seaway Lock System: Using 1976 traffic data, actual data was compared to results of the analysis. This validation was made using a ship utilization rate of 70 percent. The comparison of the number of average daily transits by month and the distribution of vessel arrivals by vessel class were acceptable.

The comparison of loaded vessel transits to total vessel transits was as follows:

	Actual	Computed
Upbound	82%	59%
Downbound	82%	70%

As with the Welland Canal Lock System, this discrepancy was not adjusted.

TABLE 10
SUMMARY OF PROJECTED ANNUAL TONNAGE*
FOR WELLAND CANAL
(THOUSANDS OF SHORT TONS)

NAV. SEASON	DIRECTION	1976**	1980	1987	1990	1991	1992	1995	2000	2020	2040
15 Apr - 15 Dec (8 months)	Downbd	38673	54905	63072	66691	68037	69464	73660	80763	110440	145681
	Upbd	25663	22167	26796	28804	29522	30256	32509	36216	56433	94981
	Total	64336	77072	89868	95495	97559	99720	106169	116979	166873	240662
1 Apr - 31 Dec (9 months)	Downbd	38673	54906	63072	68097	69483	70943	75326	82646	113586	150326
	Upbd	25663	22167	26796	29397	30130	30885	33221	37047	58091	98376
	Total	64336	77073	89868	97494	99613	101828	108547	119693	171677	248702
7 Mar - 7 Jan (10 months)	Downbd	38673	54906	63072	68097	69483	71727	76023	83346	114452	151764
	Upbd	25663	22167	26796	29397	30130	31391	33761	37696	59360	100914
	Total	64336	77073	89868	97494	99613	103118	109784	121042	173812	252678
7 Feb - 7 Jan (11 months)	Downbd	38673	54906	63072	68097	69483	71727	76023	84133	115341	153209
	Upbd	25663	22167	26796	29397	30130	31391	33761	38188	60307	102806
	Total	64336	77073	89868	97494	99613	103118	109784	122321	175648	256015

Capacity: 91.1 million tons before 1990

* Includes all commodity groups
**Actual Tonnage

Capacity conditions at the St. Lawrence Seaway were calculated by inputting the projected annual tonnage demand and allowing the vessel fleet requirements to be updated internally within the analysis so the required cargo demand could be transported in the prescribed navigation season. For a similar reason as with the Welland, extending the navigation season does not dramatically alter the date when capacity occurs at the St. Lawrence. The primary reason is that grain, other bulk, and general cargo, which comprise the majority of projected traffic on the Seaway, are shipped mostly during the normal season. Capacity is estimated to be reached shortly after the year 2000 for both the normal season and the extended seasons. The capacity estimates are depicted in Table 11.

Summary

The projected near term capacity conditions at the Welland System may limit the projected increases in grain, general cargo, and other bulk tonnages at the Soo System, because the three lock systems are treated as independent of one another.

The capacity at the Soo could be extended beyond the values indicated here without major lock improvements by:

a. minimizing the number of ballast vessel backhauls;

b. increasing vessel operating draft beyond 25.5 feet during high water periods;

c. replacing Class 10 vessels with Class 11 vessels (provided locking time does not increase); and

TABLE 11
SUMMARY OF PROJECTED ANNUAL TONNAGE*
FOR ST. LAWRENCE SEAWAY
(THOUSANDS OF SHORT TONS)

NAV. SEASON	DIRECTION	1976**	1980	1987	1990	1991	1992	1995	2000	2020	2040
15 Apr - 15 Dec (8 months)	Downbd	25588	33077	38420	40828	41690	42637	45395	50082	72060	98628
	Upbd	28818	27440	33405	36002	37038	38093	41312	46632	72123	118413
	Total	54406	60517	71825	76830	78728	80730	86707	96714	144183	217041
1 Apr - 31 Dec (9 months)	Downbd	25588	33077	38420	42097	43005	43971	46917	51807	74981	102990
	Upbd	28818	27440	33405	36591	37640	38722	42016	47455	73781	121801
	Total	54406	60517	71825	78688	80645	82693	88933	99262	148762	224791
7 Mar - 7 Jan (10 months)	Downbd	25588	33077	38420	42097	43005	44617	47467	52346	75628	104140
	Upbd	28818	27440	33405	36591	37640	39210	42543	48086	75024	124298
	Total	54406	60517	71825	78688	80645	83827	90010	100432	150652	228438
7 Feb - 7 Jan (11 months)	Downbd	25588	33077	38420	42097	43005	44617	47467	52989	76325	105337
	Upbd	28816	27440	33405	36591	37640	39210	42543	48568	75963	126177
	Total	54406	60517	71825	78688	80645	83827	90010	101557	152288	231514

Capacity: 106.7 million tons in 2000+

*Includes all commodity groups
**Actual Tonnage

d. allowing some "non-stockpiled" commodities to shift some normal season tonnage to the extended season.

Great Lakes/St. Lawrence Seaway Traffic Volume

The final element of the traffic analysis is to produce a forecast of the commodity traffic which will move through the Great Lakes/St. Lawrence Seaway system as a result of the navigation season extension proposal. Tables 9, 10, and 11 present a summary of the projected annual tonnage for each of the three lock systems. These tables portray total tonnage for all commodity movements through the locks. This is necessary since lock capacity is a function of all commodities that move through the locks and not simply those commodities which are directly affected by the proposed navigation season extension. These projections also reflect an unconstrained lock system condition. On each table the capacity level and year of occurrence of lock capacity is shown for the respective lock system.

By the year 2000, projected annual tonnage at the Soo Lock System is expected to double the 1976 tonnage level. The downbound increases in grain shipments are primarily responsible for the increases in annual traffic at the Soo in 1990 and beyond.

The annual tonnage at the Welland Canal Lock System is also expected to double the 1976 level by year 2000 with the predominance of downbound traffic expected to continue. Also, general cargo demand is expected to double its 1976 level by 1990.

At the St. Lawrence Seaway Lock System, the primary growth in annual tonnage will come from grain and general cargo traffic. Again the 1976 level of tonnage will double by 2000. Beyond 1980 the downbound iron ore traffic is expected to be greater than the upbound

shipments, reversing the past trend. Stockpiled commodities such as ore and coal are expected to experience a shift in "normal season" traffic to the extended season, while grain and general cargo shipments will not be redistributed by season extension.

The above projections are unconstrained tonnages for all commodities. In the determination of the national economic development benefits not all commodities are impacted by navigation season extension. In addition, the benefits must be calculated subject to the lock capacity conditions. Table 12 presents the projection of the capacity constrained GL/SLS traffic level by the four commodity groupings impacted by season extension. This forecast reflects the projections of the previous three tables and the individual characteristics of lock capacity of the GL/SLS system.

The effect of the lock capacity constraint can be observed in the trend of the projected annual growth rates by decade. Throughout the system, capacity at the locks is reached between 2000 and 2010. The decade following 2010 reflects a dramatic drop in the annual growth rate to 0.4%. The growth rate of the traffic movement remains at this level and does not fall to zero because there are still movements of commodities that occur within the GL/SLS system that do not pass through one of the locks. These projections of the capacity constrained GL/SLS traffic movements are used to compute the national economic development benefits.

SUMMARY OF NATIONAL ECONOMIC DEVELOPMENT BENEFITS

The normal and season-extension sensitive traffic projections are shown in Table 13, and is either redistributed from the normal season or diverted from an alternative mode. Stockpiling savings accrue to the tonnage that is redistributed (based on year-round production patterns) from the normal season. Table 14 illustrates the

TABLE 12

CAPACITY CONSTRAINED GL/SLS SEASON EXTENSION HARBOR TRAFFIC

Commodity	Forecasted Movements (Millions of Short Tons)								
	1980	1987	1990	1992	1993	1995	2000	2020	2040
Grain	15.4	16.0	17.1	17.7	17.7	18.2	18.4	19.2	19.6
Coal	37.5	47.3	52.1	54.1	55.1	56.9	61.2	72.9	80.6
Iron Ore	88.3	101.7	108.4	112.7	114.5	118.3	127.2	146.1	152.4
General Cargo	6.7	7.1	8.0	8.4	8.3	8.7	8.7	8.7	8.7
TOTAL	147.9	172.2	185.6	192.9	195.6	202.1	215.5	246.9	261.3
Annual Growth Rates Between Dates Indicated		2.2%	2.5%	1.9%	1.4%	1.7%	1.3%	0.7%	0.3%

TABLE 13

NORMAL SEASON AND EXTENDED SEASON TRAFFIC PROJECTIONS
U. S. TRAFFIC, 1980-2040
(In 1,000 Tons)

	1980	1987	1990	1992	1993	1995	2000	2020	2040
Normal Season									
Grain	14.4	14.6	14.6	14.6	14.6	14.6	14.7	15.0	15.2
Coal	37.0	46.5	50.5	52.3	52.9	53.5	55.0	61.8	64.3
Iron Ore	87.2	100.2	105.7	109.2	111.0	111.6	112.5	117.2	123.4
General Cargo	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
Total	145.3	167.9	177.5	182.7	185.1	186.3	188.8	200.6	214.6
Proposal 1 (Daylight Operation)									
Grain	15.4	16.0	16.0	16.1	16.1	16.2	16.3	17.1	17.7
Coal	37.5	47.3	51.6	53.3	54.2	55.8	60.2	71.9	79.0
Iron Ore	88.3	101.7	107.3	110.8	112.5	115.6	124.5	141.8	148.1
General Cargo	6.7	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Total	147.9	172.1	182.0	187.3	189.9	194.7	208.1	237.9	251.9
Proposal 2 (Daylight Operation)									
Grain	15.4	16.0	16.0	16.1	16.2	16.3	16.4	17.2	17.8
Coal	37.5	47.3	51.6	53.3	54.2	55.9	60.2	71.8	79.3
Iron Ore	88.3	101.7	107.3	110.8	112.6	116.1	124.9	142.6	148.8
General Cargo	6.7	7.1	7.1	7.1	7.2	7.2	7.2	7.2	7.2
Total	147.9	172.1	182.0	187.3	190.2	195.5	208.7	238.8	253.1

TABLE 13 (Cont.)

	1980	1987	1990	1992	1993	1995	2000	2020	2040
Proposal 3 (Daylight Operation)									
Grain	15.4	16.0	16.0	16.1	16.2	16.3	16.7	17.4	17.9
Coal	37.5	47.3	51.6	53.3	54.2	56.0	60.3	71.9	79.5
Iron Ore	88.3	101.7	107.3	110.9	113.3	116.7	125.5	144.1	150.5
General Cargo	6.7	7.1	7.1	7.1	7.2	7.2	7.2	7.2	7.2
Total	147.9	172.1	182.0	187.4	190.9	196.2	209.7	240.6	255.1
Proposal 4 (Daylight Operation)									
Grain	15.4	16.0	16.0	16.1	16.3	16.4	16.9	17.5	17.9
Coal	37.5	47.3	51.6	53.6	54.4	56.1	60.5	72.1	79.6
Iron Ore	88.3	101.7	107.3	111.6	113.4	116.9	125.7	144.3	150.7
General Cargo	6.7	7.1	7.1	7.2	7.3	7.3	7.3	7.3	7.3
Total	147.9	172.1	182.0	188.5	191.4	196.7	210.4	241.2	255.5
Proposal 5 (Daylight Operation)									
Grain	15.4	16.0	16.0	16.3	16.3	16.7	16.9	17.9	18.4
Coal	37.5	47.3	51.6	53.6	54.4	56.3	60.6	72.2	79.8
Iron Ore	88.3	101.7	107.3	111.6	113.7	117.1	125.9	144.5	150.9
General Cargo	6.7	7.1	7.1	7.3	7.3	7.8	7.8	7.8	7.8
Total	147.9	172.1	182.0	188.8	191.7	197.9	211.2	242.4	256.9
Proposal 6 (Daylight Operation)									
Grain	15.4	16.0	16.0	16.3	16.3	16.7	17.5	18.3	19.0
Coal	37.5	47.3	51.6	53.6	54.4	56.3	60.6	72.4	79.9
Iron Ore	88.3	101.7	107.3	111.6	113.7	117.1	126.2	144.8	152.0
General Cargo	6.7	7.1	7.1	7.3	7.3	7.8	8.1	8.1	8.1
Total	147.9	172.1	182.0	188.8	191.7	197.9	212.4	243.6	259.0

TABLE 13 (Cont.)

	1980	1987	1990	1992	1993	1995	2000	2020	2040
Proposal 2 (24 Hour Operation)									
Grain	15.4	16.0	17.1	17.2	17.2	17.3	17.4	18.2	18.7
Coal	37.5	47.3	52.1	53.8	54.7	56.4	60.8	72.5	80.1
Iron Ore	88.3	101.7	108.4	111.9	113.7	117.3	126.2	145.5	151.8
General Cargo	6.7	7.1	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Total	147.9	172.1	185.6	190.9	193.6	199.0	212.4	244.2	258.6
Proposal 3 (24 Hour Operation)									
Grain	15.4	16.0	17.1	17.2	17.3	17.4	17.5	18.4	18.8
Coal	37.5	47.3	52.1	53.8	54.8	56.6	60.9	72.6	80.3
Iron Ore	88.3	101.7	108.4	112.0	114.3	117.9	126.8	145.6	152.0
General Cargo	6.7	7.1	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Total	147.9	172.1	185.6	191.0	194.4	199.9	213.2	244.6	259.1
Proposal 4 (24 Hour Operation)									
Grain	15.4	16.0	17.1	17.7	17.7	17.8	18.0	18.8	19.3
Coal	37.5	47.3	52.1	54.1	55.0	56.7	61.1	72.8	80.4
Iron Ore	88.3	101.7	108.4	112.7	114.5	118.1	127.0	145.8	152.2
General Cargo	6.7	7.1	8.0	8.4	8.4	8.4	8.4	8.4	8.4
Total	147.9	172.1	185.6	192.9	195.6	201.0	214.5	245.8	260.3
Proposal 5 (24 Hour Operation)									
Grain	15.4	16.0	17.1	17.7	17.7	18.2	18.4	19.2	19.6
Coal	37.5	47.3	52.1	54.1	55.0	56.9	61.2	72.9	80.6
Iron Ore	88.3	101.7	108.4	112.7	114.5	118.3	127.2	146.0	152.4
General Cargo	6.7	7.1	8.0	8.4	8.4	8.7	8.7	8.7	8.7
Total	147.9	172.1	185.6	192.9	195.6	202.1	215.5	246.8	261.3

TABLE 13 (Cont.)

	1980	1987	1990	1992	1993	1995	2000	2020	2040
Proposal 6 (24 Hour Operation)									
Grain	15.4	16.0	17.1	17.7	17.7	18.2	19.0	19.9	20.2
Coal	37.5	47.3	52.1	54.1	55.0	56.9	61.4	73.1	80.7
Iron Ore	88.3	101.7	108.4	112.7	114.5	118.3	127.5	146.3	152.7
General Cargo	6.7	7.1	8.0	8.4	8.4	8.7	9.2	9.2	9.2
Total	147.9	172.1	185.6	192.9	195.6	202.1	217.1	248.5	262.8

1/ The traffic base was defined as including only that traffic which moved through the Soo Locks, the Straits of Mackinac, the St. Clair-Detroit River System or St. Lawrence Seaway after 15-December. Traffic resulting from current normal winter operations (such as intra-lake movements of petroleum and other commodities) was excluded from the analysis. Likewise, traffic not suited for winter navigation (such as limestone) excluded. The traffic projections include only traffic which is either shipped or received at a U.S. harbor.

2/ General cargo traffic affected by season extension includes prime containerized foods, chemicals, and fabricated metal products; potentially containerized food, chemicals, iron and steel products, electrical machinery and equipment, machinery except electrical, and motor vehicles and parts.

4/ DEFINITION OF PROPOSALS:

Extended Season Proposals	Estimated Starting Date of Vessel Operations	Lake Superior St. Marys River Lake Michigan Straits of Mackinac Lake Huron	St. Clair River Lake St. Clair Detroit River Lake Erie	Welland Canal Lake Ontario St. Lawrence
Base Condition	Prior to 1987	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1	1987	Year-round	1 Apr - 31 Jan	1 Apr - 15 Dec
2	1990	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3	1990	Year-round	Year-round	1 Apr - 31 Dec
4	1992	Year-round	Year-round	20 Mar - 31 Dec
5	1995	Year-round	Year-round	7 Mar - 7 Jan
6	2000	Year-round	Year-round	7 Feb - 7 Jan

NOTE: For Proposal 1, season extension was not implemented for the Welland Canal, therefore, the 24 hour operating assumption for the Welland Canal was not effective.

relationship between lock and non-lock related stockpile redistribution. The first part represents daylight operation on the Welland-Seaway in winter, while the second part represents 24 hour operation on the Welland-Seaway in winter. Also evident is the impact of lock capacity after the year 2000 on the locked portions of the traffic. Transportation rate savings accrue to the tonnage that is diverted from an alternative transportation mode to the GL/SLS. Finally, winter rate savings accrue to both the tonnage that is redistributed from the normal season, as well as the tonnage that is diverted from an alternative transportation mode. The derivation of stockpiling benefits, transportation rate benefits and winter benefits are further discussed in the following paragraphs.

Stockpiling Benefits

The extended navigation season is initially expected to materially change the annual stockpile pattern of iron ore and coal. As far as iron ore is concerned, a baseline safety stockpile is expected to remain at both the raw material source, the iron mines and pellet plants, as well as at the consumption point, the steel mills. At the pellet plants, the stockpile reaches a peak in April and is worked off gradually as shipments exceed production. Pellets are produced on a year-round basis, while shipping is curtailed during the winter. At the steel mills, the stockpile reaches a peak in December and is consumed (except for a normal safety reserve of a 60-day supply in case of an emergency, such as a strike) until normal navigation resumes.

Capital cost occurs at both the upper lakes pellet plants producing ore throughout the closed winter navigation season, and also at the steel mills which are forced to gradually build up a stockpile to enable steel production throughout the winter when the Great Lakes are closed to navigation. For iron ore, the capital cost

TABLE 14

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, DAYLIGHT OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

	1987	1990	1992	2000	2020	2040	Average Annual Benefits
Proposal 1 1/							
Tons Div. Fr. Alt. Mode 2/	2,739	2,849	3,460	18,828	38,719	39,350	17,061
Tons Ben. by Winter Rates	167,476	177,104	182,350	188,399	200,262	214,185	186,944
Tons Saved from Stockpile, Lock	4,126	4,502	10,947	11,193	11,320	11,532	9,695
Tons Saved from Stockpile, Non-Lock	1,010	1,082	1,605	1,868	2,677	3,704	1,821
Transp. Rate Savings	10,577	11,117	14,157	83,110	233,342	237,222	92,012
Winter Rate Savings	5,400	5,901	6,199	7,313	9,747	10,627	7,350
Stockpiling Savings	5,174	5,606	13,142	13,667	14,619	15,873	11,996
Total Benefits	21,151	22,624	33,498	104,090	257,708	263,722	111,358
Proposal 2 1/							
Tons Div. Fr. Alt. Mode 2/	2,739	3,829	4,422	18,378	39,229	39,818	17,341
Tons Ben. by Winter Rates	167,476	173,385	178,703	185,008	197,058	210,972	183,579
Tons Saved from Stockpile, Lock	4,126	10,524	10,947	11,193	11,320	11,532	10,619
Tons Saved from Stockpile, Non-Lock	1,010	1,540	1,605	1,868	2,677	3,704	1,892
Transp. Rate Savings	10,577	24,634	28,504	87,511	233,573	237,034	95,062
Winter Rate Savings	5,400	5,947	6,199	7,313	9,751	10,607	7,359
Stockpiling Savings	5,174	12,634	13,142	13,667	14,619	15,873	13,075
Total Benefits	21,151	43,215	47,845	108,491	257,943	263,514	115,496

TABLE 14 (Cont.)

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, DAYLIGHT OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

	1987	1990	1992	1995	2020	2040	Average Annual Benefits
Proposal 3 1/							
Tons Div. Fr. Alt. Mode 2/	2,739	3,829	4,439	8,498	19,249	40,371	17,825
Tons Ben. by Winter Rates	167,476	173,385	178,703	182,184	185,008	211,186	183,579
Tons Saved from Stockpile, Lock	4,126	10,524	10,947	20,441	20,464	20,804	17,100
Tons Saved from Stockpile, Non-Lock	1,010	1,540	1,605	3,201	3,521	7,085	3,195
Transp. Rate Savings	10,577	24,634	28,705	39,563	94,996	241,899	99,246
Winter Rate Savings	5,400	5,947	6,199	6,556	7,392	10,649	7,397
Stockpiling Savings	5,174	12,634	13,142	25,128	25,483	29,534	21,493
Total Benefits	21,151	43,215	48,046	71,247	127,871	282,082	128,136
Proposal 4 1/							
Tons Div. Fr. Alt. Mode 2/	2,739	3,829	5,435	9,319	20,366	41,422	18,714
Tons Ben. by Wint. Rates	167,476	173,385	178,703	182,370	184,819	210,972	183,579
Tons Saved from Stockpile, Lock	4,126	10,524	20,647	21,062	21,088	21,479	18,317
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,009	3,201	3,521	7,085	3,307
Transp. Rate Savings	10,577	24,634	40,723	59,336	112,097	259,633	113,052
Winter Rate Savings	5,400	5,947	6,271	6,556	7,392	10,642	7,405
Stockpiling Savings	5,174	12,634	24,859	25,502	25,859	29,933	22,695
Total Benefits	21,151	43,215	71,853	91,394	145,348	300,208	143,152

TABLE 14 (Cont.)

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, DAYLIGHT OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

	1987	1990	1992	1995	2020	2040	Average Annual Benefits
Proposal 5 1/							
Tons Div. Fr. Alt. Mode 2/	2,739	3,829	5,446	10,033	21,467	42,448	19,398
Tons Ben. by Winter Rates	167,476	173,385	178,703	182,370	184,819	210,972	183,392
Tons Saved from Stockpile, Lock	4,126	10,524	20,647	21,706	21,735	22,179	18,726
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,009	3,201	3,521	7,085	3,307
Transp. Rate Savings	10,577	24,634	41,098	71,259	129,506	276,969	123,916
Winter Rate Savings	5,400	5,947	6,271	6,656	7,392	10,637	7,405
Stockpiling Savings	5,174	12,634	24,859	26,356	26,719	30,864	23,239
Total Benefits	21,151	43,215	72,228	104,271	163,617	318,470	154,560
Proposal 6 1/							
Tons Div. Fr. Alt. Mode 2/	2,739	3,829	5,466	10,114	22,965	43,842	20,114
Tons Ben. by Winter Rates	167,476	173,385	178,521	182,184	184,631	210,972	183,392
Tons Saved from Stockpile, Lock	4,126	10,524	21,011	21,706	22,683	23,204	19,195
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,073	3,201	3,521	7,085	3,307
Transp. Rate Savings	10,577	24,634	41,275	72,716	154,522	302,313	136,259
Winter Rate Savings	5,400	5,947	6,271	6,656	7,392	10,630	7,404
Stockpiling Savings	5,174	12,634	25,314	26,356	27,765	31,997	23,757
Total Benefits	21,151	43,215	72,860	105,728	189,679	344,940	167,420

TABLE 14 (Cont.)

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, 24 HOUR OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

	1987	1990	1992	2000	2020	2040	Average Annual Benefits
Proposal 2 1/							
Tons Div. Fr. Alt. Mode 2/	4,721	8,546	8,653	24,024	43,930	44,390	22,118
Tons Ben. by Wint. Rates	167,476	177,104	182,350	188,399	200,262	14,185	186,944
Tons Saved from Stockpile, Lock	4,126	10,524	10,947	11,193	11,320	11,532	10,619
Tons Saved from Stockpile, Non-Lock	1,010	1,540	1,605	1,868	2,677	3,704	1,892
Transp. Rate Savings	14,174	66,398	66,912	135,886	286,241	288,714	141,883
Winter Rate Savings	5,400	5,947	6,199	7,313	9,751	10,607	7,359
Stockpiling Savings	5,174	12,634	13,142	13,667	14,619	15,873	13,075
Total Benefits	24,748	84,979	86,253	156,866	310,611	315,194	162,317
Proposal 3 1/							
Tons Div. Fr. Alt. Mode 2/	4,721	8,546	8,653	24,870	44,341	44,907	22,563
Tons Ben. by Wint. Rates	167,476	177,104	182,350	188,399	200,262	214,185	186,944
Tons Saved from Stockpile, Lock	4,126	10,524	10,947	20,464	20,592	20,804	17,100
Tons Saved from Stockpile, Non-Lock	1,010	1,540	1,605	3,521	5,101	7,085	3,195
Transp. Rate Savings	14,174	66,398	66,912	143,716	290,545	293,567	146,165
Winter Rate Savings	5,400	5,947	6,199	7,392	9,789	10,649	7,397
Stockpiling Savings	5,174	12,634	13,142	25,483	27,258	29,534	21,493
Total Benefits	24,748	84,979	86,253	176,591	327,592	333,750	175,055

*Note - Proposal 1 does not extend to Welland - Seaway, therefore, the 24-hour operating assumptions for Welland - Seaway are not effective.

TABLE 14 (Cont.)

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, 24 HOUR OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

	1987	1990	1992	1995	2000	2040	Average Annual Benefits
Proposal 4 1/							
Tons Div. Fr. Alt. Mode 2/	4,721	8,546	10,554	15,079	26,043	46,076	23,540
Tons Ben. by Wint. Rates	167,476	177,104	182,350	185,902	188,399	214,185	186,944
Tons Saved from Stockpile, Lock	4,126	10,524	20,647	21,062	21,088	21,479	18,317
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,009	3,201	3,521	7,085	3,307
Transp. Rate Savings	14,174	66,398	93,832	112,380	163,885	313,566	162,431
Winter Rate Savings	5,400	5,947	6,271	6,656	7,392	10,642	7,405
Stockpiling Savings	5,174	12,634	24,859	25,502	25,859	29,933	22,695
Total Benefits	24,748	84,979	124,962	144,538	197,136	354,141	192,531
Proposal 5 1/ (Proposed Plan)							
Tons Div. Fr. Alt. Mode 2/	4,721	8,546	10,554	16,209	27,173	47,164	24,248
Tons Ben. by Wint. Rates	167,476	177,104	182,350	185,902	188,399	214,185	186,944
Tons Saved from Stockpile, Lock	4,126	10,524	20,647	21,706	21,735	22,179	18,726
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,009	3,201	3,521	7,085	3,307
Transp. Rate Savings	14,174	66,398	93,832	132,452	183,958	333,296	175,022
Winter Rate Savings	5,400	5,947	6,271	6,656	7,392	10,642	7,405
Stockpiling Savings	5,174	12,634	24,859	26,356	26,719	30,864	23,239
Total Benefits	24,748	84,979	124,962	165,464	218,069	374,802	205,666

TABLE 14 (Cont.)

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, 24 HOUR OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

Proposal 6 1/	1987	1990	1992	1995	2000	2040	Average Annual Benefits
Tons Div. Fr. Alt. Mode 2/	4,721	8,546	10,554	16,209	28,742	48,713	25,017
Tons Ben. by Wint. Rates	167,476	177,104	182,350	185,902	188,399	214,185	186,944
Tons Saved from Stockpile, Lock	4,126	10,524	21,011	21,706	22,683	23,204	19,195
Tons Saved from Stockpile, Non-Lock	1,010	1,540	3,073	3,201	3,521	7,085	3,307
Transp. Rate Savings	14,174	66,398	93,832	132,452	212,547	361,618	188,986
Winter Rate Savings	5,400	5,947	6,271	6,656	7,392	10,630	7,404
Stockpiling Savings	5,174	12,634	25,314	26,356	27,765	31,997	23,757
Total Benefits	24,748	84,979	125,417	165,464	247,704	404,245	220,147

1/ Definition of Proposals:

Extended Season Proposals	Estimated Starting Date of Vessel Operations	Lake Superior, St. Marys River, Lake Michigan, Straits of Mackinac, Lake Huron	St. Clair River, Lake St. Clair, Detroit River, Lake Erie	Welland Canal, Lake Ontario, St. Lawrence River
Base Condition	Prior to 1987	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1.	1987	Year-round	1 Apr - 31 Jan	1 Apr - 15 Dec
2.	1990	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3.	1990	Year-round	Year-round	1 Apr - 31 Dec
4.	1992	Year-round	Year-round	20 Mar - 31 Dec
5.	1995	Year-round	Year-round	7 Mar - 7 Jan
6.	2000	Year-round	Year-round	7 Feb - 7 Jan

TABLE 14 (Cont.)

TOTAL ANNUAL U.S. BENEFITS FROM NAVIGATION SEASON EXTENSION, 24 HOUR OPERATION ON WELLAND-SEAWAY IN WINTER
(In $1,000 at 7-1/8%, and In 1,000 Tons)

2/ See Table 22 for breakdown of diverted tons by commodity group.

NOTE: The Chief of Engineer's recommendation on the March 1976 Interim Feasibility Report recommends an extended season program on the upper four Great Lakes to 31 January (± 2 weeks). This is the Base Condition shown above.

The word "Proposal" identifies sub-divisions of an overall plan. These proposals have not been developed as exclusive alternatives.

saving associated with the proposed plan to extend the navigation season is computed by multiplying the cost per short ton (about \$32.70 at the upper lakes pellet plants and \$40.40 at the steel mills - the latter including transport cost to the steel mill) times the interest rate (7-1/8%) times the percent of time a ton is not in the stockpile because of winter navigation (6.2429 months/12 months = 52.0% at the steel mills and 5.0131 months/12 months = 41.8% at the pellet plants). This calculates to a \$1.50 per ton saving at the steel mills and \$0.97 per ton savings at the pellet plants. Handling charge savings of \$1.25 per short ton were also claimed as a benefit on the approximately 25% of shipments to inland steel mills which require an extra loading or unloading, unlike lakefront mills. Stockpile related benefits for season extension are shown in Table 14. Tables 15A and 15B display the methodology used to compute the number of months a ton is saved from the stockpile at the pellet plants and steel mills, respectively, for the proposed plan.

As far as coal is concerned, navigation season extension is expected to also change the annual tons stockpiled at coal steam electric power plant facilities. With the closed navigation season, stockpiles at the power plants reach a peak in December and are consumed until normal navigation resumes. With season extension, coal stockpiles will be significantly reduced, although baseline safety stockpiles will remain, and there will be a capital cost savings of \$0.84 per ton associated with the proposed plan, based on a cost per short ton for coal of \$23.50, an interest rate of 7-1/8%, and 50.2% time saving (6.02415 months/12 months) that a ton is not in the stockpile. Savings in handling charges were not considered for coal because of existing coal stockpile storage patterns. Table 15C depicts the derivation of months saved from the stockpile for coal, for the proposed plan.

The extended navigation season reduced benefits related to stockpile reduction and redistribution are of value only to the point

TABLE 15A

STOCKPILE SAVINGS FOR SEASON ENDING

31 MARCH

IRON ORE MINES AND PELLET PLANTS

PERIOD	NEED PER MONTH	NORMAL SEASON RECEIPTS	NORMAL SEASON INCREMENTAL INVENTORY	NORMAL SEASON ACCUMULATED INVENTORY	EXTENDED SEASON RECEIPTS	EXTENDED SEASON INCREMENTAL INVENTORY	EXTENDED SEASON ACCUMULATED INVENTORY	STOCKPILING SAVINGS	SAVINGS (TON-MONTHS)
MAY	.09700	.12400	-.02700	.22800	.10391	-.00691	.09613	.13187	.13187
JUNE	.10000	.13400	-.03400	.19400	.11229	-.01229	.08384	.11016	.11016
JULY	.09300	.13400	-.04100	.15300	.11229	-.01929	.06455	.08845	.08845
AUGUST	.09400	.13400	-.04000	.11300	.11229	-.01829	.04626	.06674	.06674
SEPTEMBER	.09400	.12400	-.03000	.08300	.10391	-.00991	.03634	.04666	.04666
OCTOBER	.08600	.11300	-.02700	.05600	.09469	-.00869	.02765	.02835	.02835
NOVEMBER	.07900	.10300	-.02400	.03200	.08631	-.00731	.02034	.01166	.01166
DECEMBER 1-15	.04000	.07200	-.03200	0	.06034	-.02034	0	0	0
DECEMBER 16-31	.03900	0	.03900	.03900	.02500	.01400	.01400	.02500	.01250
JANUARY	.06600	0	.06600	.10500	.05500	.01100	.02500	.08000	.08000
FEBRUARY	.06300	0	.06300	.16800	.04100	.02200	.04700	.12100	.12100
MARCH	.07500	0	.07500	.24300	.04100	.03400	.08100	.16200	.18200
APRIL	.07400	.06200	.01200	.25500	.05196	.02204	.10304	.15196	.15196
TOTAL	1.00000	1.00000			1.00000				1.01135

$$\text{AVERAGE AGE OF STOCKPILE} = \frac{\text{(TON MONTHS SAVED)}}{\text{(WINTER TRAFFIC)}} = \frac{1.01135}{.16200} = 6.24290$$

TABLE 15B

STOCKPILE SAVINGS FOR SEASON ENDING

31 MARCH

IRON AND STEEL MILLS

PERIOD	NEED PER MONTH	NORMAL SEASON RECEIPTS	NORMAL SEASON INCREMENTAL INVENTORY	NORMAL SEASON ACCUMULATED INVENTORY	EXTENDED SEASON RECEIPTS	EXTENDED SEASON INCREMENTAL INVENTORY	EXTENDED SEASON ACCUMULATED INVENTORY	STOCKPILING SAVINGS	SAVINGS (TON-MONTHS)
MAY	.09200	.12400	.03200	.03200	.10391	.01191	.01191	.02009	.02009
JUNE	.08500	.13400	.04900	.08100	.11229	.02729	.03920	.04180	.04180
JULY	.08200	.13400	.05200	.13300	.11229	.03029	.06950	.06350	.06350
AUGUST	.07900	.13400	.05500	.18800	.11229	.03329	.10279	.08521	.08521
SEPTEMBER	.07900	.12400	.04500	.23300	.10391	.02491	.12770	.10530	.10530
OCTOBER	.08300	.11[illegible]0	.03000	.26300	.09469	.01169	.13939	.12361	.12361
NOVEMBER	.07900	.10300	.02400	.28700	.08631	.00731	.14671	.14029	.14029
DECEMBER 1-15	.04000	.07200	.03200	.31900	.06034	.02034	.16704	.15196	.07598
DECEMBER 16-31	.04000	0	-.04000	.27900	.02500	-.01500	.15204	.12696	.06348
JANUARY	.08300	0	-.08300	.19600	.05500	-.02800	.12404	.07196	.07196
FEBRUARY	.07900	0	-.07900	.11700	.04100	-.03800	.08604	.03096	.03096
MARCH	.09000	0	-.09000	.02700	.04100	-.04900	.03704	-.01004	-.01004
APRIL	.08900	.06200	-.02700	0	.05196	-.03704	0	0	0
TOTAL	1.00000	1.00000			1.00000				.81212

$$\text{AVERAGE AGE OF STOCKPILE} = \frac{\text{(TON MONTHS SAVED)}}{\text{(WINTER TRAFFIC)}} = \frac{.81212}{.16200} = 5.01310$$

TABLE 15C

STOCKPILE SAVINGS FOR SEASON ENDING

31 MARCH

COAL FOR GREAT LAKES CONSUMERS

PERIOD	NEED PER MONTH	NORMAL SEASON RECEIPTS	NORMAL SEASON INCREMENTAL INVENTORY	NORMAL SEASON ACCUMULATED INVENTORY	EXTENDED SEASON RECEIPTS	EXTENDED SEASON INCREMENTAL INVENTORY	EXTENDED SEASON ACCUMULATED INVENTORY	STOCKPILING SAVINGS	SAVINGS (TON-MONTHS)
MAY	.08000	.13500	.05500	.07200	.10908	.02908	.02908	.04292	.04292
JUNE	.08300	.13500	.05200	.12400	.10908	.02608	.05516	.06884	.06884
JULY	.08900	.11500	.02600	.15000	.09292	.00392	.05908	.09092	.09092
AUGUST	.09000	.12500	.03500	.18500	.10100	.01100	.07008	.11492	.11492
SEPTEMBER	.08200	.12500	.04300	.22800	.10100	.01900	.08908	.13892	.13892
OCTOBER	.08200	.12500	.04300	.27100	.10100	.01900	.10808	.16292	.16292
NOVEMBER	.08200	.10400	.02200	.29300	.08403	.00203	.11011	.18289	.18289
DECEMBER 1-15	.04500	.04200	-.00300	.29000	.03394	-.01106	.09905	.19095	.09548
DECEMBER 16-31	.04500	0	-.04500	.24500	.02500	-.02000	.07905	.16595	.08298
JANUARY	.08700	0	-.08700	.15800	.05500	-.03200	.04705	.11095	.11095
FEBRUARY	.07800	0	-.07800	.08000	.06200	-.01600	.03105	.04895	.04895
MARCH	.08000	0	-.08000	0	.05000	-.03000	.00105	-.00105	-.00105
APRIL	.07700	.09400	.01700	.01700	.07595	-.00105	0	.01700	.01700
TOTAL	1.00000	1.00000			1.00000				1.15664

$$\text{AVERAGE AGE OF STOCKPILE} = \frac{\text{(TON MONTHS SAVED)}}{\text{(WINTER TRAFFIC)}} = \frac{1.15664}{.19200} = 6.02415$$

where lock capacity at Sault Ste. Marie is sufficient to handle the redistributed traffic with a combination of winter and summer months. As a result of capacity studies, stockpile related benefits are held constant, for the lock related traffic, at the year 2000 traffic level. This is consistent with capacity study findings that lock capacity on the Soo will be reached at or about 1990 without season extension and at or about 2005 with season extension.

Transportation Rate Benefits

The tonnage that is diverted from alternative modes with navigation season extension is determined by rate/service factors competitive advantage. Transportation rate differentials are applied to each commodity group on the basis for determining project benefits. The differential is the transportation rate savings associated with season extension without the adjustment for winter rates. Transportation rate savings are based on the least-cost routing from origin to destination. Line haul rail or truck costs to the port of exit, port terminal charges, and ocean and laker tariffs are all included. All measurement and weight units were converted to hundredweights. Tonnage and related savings associated with navigation season extension are shown in Table 14.

Winter Rate Benefits

In the winter rate study for the Great Lakes-St. Lawrence Seaway conducted as part of the season extension survey, the total transit time for ships navigating a technically feasible Great Lakes-St. Lawrence Seaway System was estimated during the winter season and translated into total transit times and vessel operating costs with the associated required freight rates for the major commodity routes. For example, in 1975, the budget cost for a 1,000-foot vessel was $33 million. Fixed capital costs for this vessel are $16,300 a day for a

nine-month shipping season. Daily variable operating expenses are about $12,600 for the nine-month season. Daily operating expenses are as follows: (1) fuel accounts for 50%; (2) wages, subsistence and stores about 18%; and (3) insurance, maintenance, tug charges, and lay-up account for the remaining 32%. With extended navigation season operations, the winter rate study showed that for inland bulk cargo routes, annual required freight rates with season extension decreased an average of 8% for all routes and all commodities for the 1975 fleet and normal winter, with the greatest reduction (over 11%) occurring for all-year shipping of iron ore from Escanaba to Indiana Harbor. This was despite the fact that operating costs per ton tended to increase with season extension. The largest operation cost increase was 13%, occurring for all-year shipping of iron ore from Sept Iles, Quebec, to Cleveland, Ohio. In essence, therefore, shippers would enjoy a savings in the annual cost of moving bulk commodities from an extension of the navigation season because the extra operating costs are more than offset by the extra revenue generated through year-round use of the vessels.

Winter rate savings, as shown in Table 14, were claimed on the estimated reduction in annual Great Lakes freight rates on the following bulk commodity movements: (1) iron ore and coal shipments that would be redistributed over the 12-month navigation season due to the reduced stockpiling requirements associated with winter navigation; and (2) a small amount of iron ore and coal traffic that is currently railed to consumers on an emergency basis during the closed navigation season, but would be diverted to the Great Lakes with navigation season extension (thereby permitting the year-round use of Great Lakes vessels to transport this traffic).

Winter rate savings accruing to these affected bulk commodity movements were computed by applying the percent reduction in annual

Lakes freight rates on these routes to the current annual Great Lakes freight rates for all of the affected movements.

Whereas for inland bulk cargo routes the annual required freight rates decreased with season extension, the rate increased for overseas grain and general cargo routes, with a maximum increase of seven percent for all-year shipping of grain and a three percent rise for all-year shipping of general cargo. Annual required freight rates for overseas cargo increase with season extension because overseas vessels are assumed to have alternative employments during the winter. The users of the Great Lakes navigation season in the winter will optimize their shipment plans to obtain the lowest overall transportation costs. Therefore, all overseas shippers with negative savings on an annual basis because of higher annual rates associated with Great Lakes winter overseas movements will not use shipping lines that operate during the winter, but continue to use the Great Lakes during the normal season and the least cost alternative during the winter. It should be noted, however, that winter navigation will open additional operational options to overseas cargo shippers that would be subject to a laker annual required freight rate and not an overseas vessel annual required freight rate. These options include: (1) shifts in grain trade from direct overseas movements to laker movements on the St. Lawrence River and then transshipped overseas, and (2) general cargo laker feeder operations. Where cost-effective vs. the least-cost transport alternative, winter rate savings associated with these laker feeder options were included in the benefits evaluated for season extension.

It should be noted that the study of winter operations also determined that as the Great Lakes fleet mix tends to larger, more economical ships, the required freight rate decreases even more for inland bulk cargo routes and increases less for overseas routes. However, these potential freight rate savings stemming from future

fleet mix changes were not included in the benefits evaluated for this project.

Total Benefits of Alternative Proposals

The computation of the stockpiling, transportation rate and winter rate savings associated with the proposals to extend the navigation season, including the proposed plan of season extension, are summarized in Table 14.

In addition to the six proposals outlined in Table 14, the iterative survey report process has examined a number of alternatives in previous report drafts. Specific alternatives of traffic volume, vessel utilization and distribution patterns have been examined in previous draft reports.

In this, the final report on GL/SLS Navigation Season Extension, a range of benefits is displayed based upon operational plans involving: (1) 24-hour navigation on the entire GL/SLS, and (2) 24-hour navigation on the upper Great Lakes with daylight only operations on the St. Lawrence Seaway.

Comments on previous levels of traffic and vessel utilization have been incorporated into this final report. As a result, previous assumptions of optimization of vessel utilization and shifting of grain traffic into winter months have been eliminated. Thus, the more conservative vessel utilization and winter traffic potential alternatives have been incorporated into the final analysis.

POSSIBLE NEGATIVE BENEFITS

Concerns expressed regarding possible negative benefits of season extension on (1) the environment (such as changes in fish and

wildlife habitat population, and aesthetic values), and (2) on winter recreational use of lakes, harbors and channels, have not yet been identified and quantified. As potential impacts and mitigation measures are identified and quantified, these costs will be included in the benefit/cost ratio as specified by the Programmatic EIS and Adaptive Method. The benefit/cost ratio does include the estimated amount for the Environmental Plan of Action (EPOA) and a winter recreation study, both of which are to be initiated in the advanced engineering and design phase. Implementation of these studies would provide information as to the quantification of environmental/recreational disbenefits associated with the proposed program. To date, no disbenefits have been identified which would substantially alter the benefit/cost ratio. However, if environmental/recreational disbenefits become quantified during the advanced engineering and design phase, the dollar amount will be included in the benefit/cost ratio.

Regional Disbenefits to Alternative Modes

As mentioned in the paragraphs on regional benefits, navigation season extension will divert future expected traffic away from rail and trucking industries and Eastern and Gulf ports toward the GL/SLS system. In order to determine what impact the diverted tonnage would have on the various transport modes and regions concerned, an Intermodal Impact Study was undertaken and is described below in this appendix. It should be noted that any regional disbenefits represent a regional transfer of income away from other transport modes and regions of the country to the Great Lakes Region and, as such, are not included in the proposed plan's overall benefit/cost ratio.

SECONDARY REGIONAL IMPACTS

Regional Benefits to Great Lakes Ports

The Regional Economic Benefit Analysis determines the regional impact of navigation season extension on the Great Lakes Region. This analysis depicts the regional benefits and employment accruing directly to individual Great Lakes ports, as well as the regional economies surrounding these ports. It is essential to note that these regional benefits only represent regional transfers of income to the Great Lakes Region from other regions of the country, based on that traffic which would be diverted to the GL/SLS from other transportation modes as a result of season extension. As such, these regional benefits are not included in the proposed plan's overall benefit/cost ratio, which only addresses net increases in the nation's overall efficiency in the transportation of goods (as reflected in the project's primary, transportation-related benefits).

Table 16 summarizes the results of the Regional Economic Benefits Analysis by showing the regional benefits and additional port jobs that would accrue to the entire Great Lakes Region as a result of the proposed plan to extend the navigation season. (Note: Port jobs added include longshoremen, stevedores, terminal operators, merchant seamen, ship and equipment repair personnel, freight forwarders and agents, steamship company personnel, and pilot and port administrators.)

TABLE 16

REGIONAL BENEFITS AND PORT JOBS ADDED IN THE GREAT LAKES REGION FROM THE PROPOSED PLAN ($1,000 AND ACTUAL NUMBER OF JOBS)

CATEGORY	1987	1990	1995	2000	2020	2040
Regional Benefits	$126,979	$248,091	$370,290	$418,145	$508,993	$514,655
Port Jobs	1,804	3,262	4,328	4,391*	3,107*	1,751*

* After 2010, benefits increase at a very slow rate because the GL/SLS system is near capacity. Earnings per new employee escalate further than benefits; therefore, additional employment decreases.

ENERGY IMPACTS

Energy Impact Study

The Energy Impact Analysis determines the effect that navigation season extension would have on energy consumption. Specifically, this study compared the energy consumption associated with winter waterborne movement of bulk and general cargo during an extended navigation season to the energy consumption associated with winter movement of the same commodities via the least-cost alternative transport mode (rail, truck, barge). All line haul movements were specified as origin to destination movements shipped either via a GL/SLS routing or an alternative transport mode routing. The analysis measured the change that extended season navigation would have on the energy consumed in line haul freight operations as a result of: (1) traffic being diverted to the GL/SLS System from

alternative transport modes, and (2) Great Lakes traffic being redistributed from the normal seasons to the winter season as a result of altered stockpiling patterns. Included in the analysis were the increased transit times and delays that would be associated with winter naviation operation for the various size vessels in the Great Lakes and overseas fleets, as well as the energy expended by the facilities and operations (the infrastructure) required to support winter navigation.

Table 17 summarizes the results of the Energy Study. As shown in this table, the study concludes that there would be a small, but positive, energy impact associated with the increased GL/SLS waterborne movement that would result from an extended navigation season. More importantly, it is felt that the conservative assumptions taken throughout this study (e.g., GL/SLS energy consumption was based on severe winter conditions; also, for the alternative route, the nearest or least circuitous ocean port was selected for transhipment overseas) assure that the conclusion would not be reversed by any reasonable change in the assumptions underlying the analysis.

Power Production

As far as the impact of winter navigation on power production is concerned, the expected ice condition with the proposed plan of improvement in operation is expected to maintain normal water levels and flows; therefore, there would be no impact on power on the upper lakes. The ice control proposed for the St. Lawrence River should eliminate the severe ice dam problem in that river and, therefore, would provide a benefit to power through increased head and the maintenance of outflow capability.

TABLE 17

SUMMARY OF NAVIGATION SEASON EXTENSION ENERGY IMPACTS[1/]
(BILLIONS OF BTU'S PER YEAR)

ENERGY IMPACT AREA	1990	2000	2010	2020	2030
Normal Season Line Haul					
GL/SLS	58,753	64,416	67,677	70,350	72,795
Alt. Transport Mode	500,851	748,822	1,062,939	1,409,263	1,772,418
Total Norm. Seas. Line Haul	559,604	813,238	1,130,616	1,479,613	1,845,213
Extended Season Line Haul					
GL/SLS	59,936	72,623	87,880	90,986	93,934
Alt. Transport Mode	498,955	739,705	1,041,522	1,387,092	1,749,313
Total Ext. Seas. Line Haul	558,891	812,328	1,129,402	1,478,078	1,843,247
Net Line Haul Savings	713	910	1,214	1,535	1,966
Less Infrastructure Energy Use:					
Ice Breakers	373	459	459	459	459
Air Reconnaissance	21	21	21	21	21
Bubblers	59	59	59	59	59
Local Tugs	8	34	80	78	79
Tugs at Locks	99	99	99	99	99
Semi-Permanent Ice Controls	38	38	38	38	38
Other Associated Impacts	52	52	52	52	52
Total Infrastructure Costs	650	762	808	806	807
Net Energy Savings	63	148	406	729	1,159

1/The energy impacts displayed in this table cover season extension beyond the base condition assumed for this report. Possible energy savings to be gained by implementing the recommendation in the March 1976 Interim Report (January 31 plus or minus two weeks on the upper four Great Lakes) are not contained in this analysis.

REGIONAL ECONOMIC ANALYSIS

This analysis utilizes the results presented in the study titled Benefits of Great Lakes Season Extension, prepared for the U.S. Army Corps of Engineers by Booz, Allen and Hamilton, Inc., Bethesda, Maryland, August 31, 1978. The analysis concentrated on the three areas of port related direct benefits, regional multipliers and induced production. The results of the research are described below.

Port Related Initial Economic Benefits

Direct benefits are those generated directly by the movement of cargo through a port. The economic benefit factors differ both by commodity and by port. These differences are due to several factors. The principal bulk commodities handled at each port, and the volume and type of handling, differ considerably. Finally, labor costs vary among all ports.

Regional Multipliers

The initial funds described above represent the purchase of goods and services essential for the movement of cargo through a port. This revenue is in turn respent within the regional economy for other goods and services. Regional multipliers are measures of how many times direct benefits are respent. For instance, a multiplier of 2.6 indicates that for each dollar spent to move cargo, an additional $1.60 worth of goods and services are purchased in the local or regional economy.

The geographic regions of the BEA study (BEA regions) are smaller than the areas used in University of Wisconsin Sea Grant Program Report 16 (states). These areas are identified in Table 18, with BEA regions identified by number and state.

TABLE 18

INDUSTRY SPECIFIC GROSS OUTPUT MULTIPLIERS AND COMPONENTS

FOR THE TRANSPORTATION SECTOR BY BEA ECONOMIC AREAS

City and State (BEA Region)	Gross Outer Multiplier
Syracuse, New York (7)	2.285
Rochester, New York (8)	2.173
Buffalo, New York (9)	2.520
Erie, Pennsylvania (10)	2.172
Cleveland, Ohio (68)	2.720
Toledo, Ohio (70)	2.370
Detroit, Michigan (71)	2.710
Saginaw, Michigan (72)	2.090
Grand Rapids, Michigan (73)	2.280
Lansing, Michigan (74)	2.160
South Bend, Indiana (76)	2.210
Chicago, Illinois (77)	3.028
Milwaukee, Wisconsin (84)	2.510
Appleton-Oshkosh, Wisconsin (85)	2.234
Duluth-Superior, Minnesota-Wisconsin (87)	2.123

SOURCE: U. S. Water Resources Council, Guideline 5, Regional Multipliers (prepared by the U.S. Department of Commerce, Bureau of Economic Analysis), January 1977, Appendixes B and C.

The two principal bulk commodities moving via the Great Lakes system in domestic trade are iron ore and coal which account for about 70 percent of domestic lake traffic. These commodities have the following in common:

a. supply sources are concentrated in a limited number of locations;

b. consumption points, while in well-established locations, are widely distributed nationwide; and,

c. both commodities are raw materials used as input to manufacturing or power generation; the products of these activities are marketed on a nationwide rather than a regional basis.

Only 6 percent of domestic coal production is carried on the Great Lakes. For this reason alone, season extension will probably not cause a measurable national increase in coal consumption.

Another factor mitigates against an increase in coal usage due to season extension. Electricity generation accounts for about 70 percent of domestic coal consumption, and the demand for electricity has historically been insensitive to small changes in price.

As noted previously, season extension is expected to reduce lake freight rates by 7 to 12 percent. The impact of this reduction on the delivered price of ore is 1 percent.

Steel prices are influenced by a variety of market factors in addition to the cost of raw materials. It is doubtful that any increase in national steel production will be caused by the lake freight rate reducitons resulting from season extension.

While rate reductions due to season extension will probably not impact national levels of iron ore and coal consumption, it is possible that on a regional basis such rate reductions may enable industries which consume ore and coal to compete in new markets and thus increase production. To determine the extent to which this might occur would require an analysis of the competitive marketing economics of each major industrial production center which consumes ore or coal.

In conclusion, it should be stressed that while the transportation rate reductions stemming from season extension may not have a multiplier effect in terms of inducing additional national production of iron ore and coal, these rate reductions of themselves still represent released resources (due to a net increase in the nation's overall efficiency in the transportation of goods) which can be employed elsewhere in the national economy for the production of goods and services. It is for this very reason that these rate reductions are considered national economic development benefits and are included in the project's benefit/cost ratio.

Methodology and Benefits Calculation

Initial Economic Benefits for Ports

Initial economic benefits are a measure of the purchases of goods and services directly required to support the movement of waterborne traffic through a port. These expenditures normally include terminal and handling charges, stevedore costs, and other services (related to getting a vessel into and out of a port).

The matrix of benefit factors was developed in three steps. First, the commodity-specific benefit factors from the following port studies:

a. Chicago,

b. Green Bay,

c. Saginaw, and

d. Detroit (general cargo only),

were updated to 1977 dollars by applying adjustments for inflation between 1977 and the year each port study was performed.

While no comparable sources of benefit factors for other major lake ports are available, one important source of economic benefits can be determined for these ports, namely expenditures for terminals, handling and stevedoring services. Terminal-related costs form a large part of the total benefit accruing from cargo traffic, and are representative of the differences in total benefits at various ports. Table 19 shows that for general and bulk cargo, benefits from terminal, handling, and stevedore services comprise a large percent of total direct benefits.

The second step in developing a complete matrix of benefit factors consisted of extending the cost information contained in the port studies to other major lake ports. This extension was performed by:

a. identifying cargo handling and ship alongside costs at five other major lake ports;

b. determining the relationship between cargo handling and ship alongside costs at these other ports, compared to a port (Chicago) where both cargo handling, ship alongside costs and total benefits were known; and,

c. estimating total benefit factors for these other major ports.

TABLE 19

COMPARISON OF TERMINAL TO TOTAL DIRECT BENEFITS

Port	Commodity	Terminal ($/Ton)	Total ($/Ton)	Percent Terminal to Total
Chicago	Grain	4.44	5.26	84%
	Iron Ore	0.40	0.45	89%
	Other Dry Bulk	1.05	1.65	64%
	General Cargo	29.39	39.21	75%
Green Bay	General Cargo	15.40	23.92	64%
Saginaw	General Cargo	12.40	23.02	54%
Tampa*	Coal	1.25	1.72	73%
	Other Dry Bulk	1.25	1.53	82%

* While not a Great Lakes port, the relationship is similar.

SOURCES: Chicago, Green Bay, Saginaw: port studies cited previously.
Tampa: draft report: Economic Impact Study of the Port of Tampa. Booz, Allen & Hamilton.

General cargo: Booz, Allen identified terminal, handling and ship alongside costs for a typical liner operator at various Great Lakes ports in the Port of Chicago study. These costs are slightly higher than the terminal costs because they include an additional element measuring the cost to remain at the pier. These costs were used to establish ratios between terminal-related costs at Chicago and other ports. These ratios were then applied to the general cargo benefit factor for Chicago ($47.60)* to develop general cargo benefit factors for the other five ports, as shown in Table 20. A similar methodology was used for bulk commodities.

Regional Multipliers

The initial benefits described above represent injections into a local port economy caused by an external activity (waterborne cargo traffic). Regional multipliers measure the respending of those initial benefits by taking into account:

a. interconnections between industry in the region;

b. implications of increased regional household income; and,

c. resulting household consumption expenditures in the region.

* Developed from the benefit factor from Table 18 above, adjusted to 1978 dollars.

TABLE 20

BENEFIT FACTORS BY PORT AND COMMODITY ($/ton)

Port	Cargo Type			
	Grain	Coal	Iron Ore	General Cargo
Chicago, Calumet, Gary**	6.39	1.48	.55	47.60***
Indiana Harbor, Burns Harbor, Buffington	-	-	.55	30.47
Milwaukee, Port Washington	6.39	-	-	46.19
Saginaw, Alpena, Calcite, Stoneport, other Lake Huron**	13.19	-	4.27*	-
Green Bay**	-	5.52*	-	-
Muskegon, Ludington, Grand Haven, other Lake Michigan	13.19	-	-	-
St. Clair, Detroit, other Detroit River**	4.83	1.29	.47	50.59
Toledo, Sandusky, Huron, Lorain, Monroe, other Lake Erie	4.83	1.48	.47	25.21
Cleveland, Ashtabula, Conneaut Erie, Buffalo, Fairport, Marblehead, Oswego, Rochester, other Lake Ontario	4.83	1.29	.47	31.41
Two Harbors, Duluth, Presque Isle, Marquette, Taconite, Silver Bay, Ashland, Escanaba, Port Dolomite, Port Inland, Drummond Island, other Lake Superior	4.64	2.13	.85	33.78

* Dry Bulk Rate (not specific to commodity)
** Direct benefit from port study
*** General cargo direct benefit from port study

The Regional Economic Analysis Division of the Bureau of Economic Analysis employs a modified input/output model. The multipliers are specific to the transportation sector and are based on BEA economic regions.

Input/output models are based on a matrix which shows the relationship among all sectors of an economy. The matrix contains coefficients which identify the intermediate sources of supply and demand for each industry. Given a set of final demand variables, this matrix can be used to solve for all the interindustry transactions which satisfy those final demands. The coefficient matrix can be used to compute a respending multiplier for any sector of the economy by identifying relative purchase levels of that sector from other sectors.

Benefits Calculation

The benefits calculations are divided into three categories:

a. direct economic benefits (due to port activity);

b. other economic benefits (due to multiplier effect); and,

c. additional employment.

The calculation is best illustrated by the following example. Direct benefits were calculated as follows:

a. additional (diverted) tonnage - 10,000 tons;

b. benefit factor related to port activity (based on commodity and port) - $40/ton;

c. total direct initial local benefit - $400,000;

d. regional multiplier (based on port); and,

e. total direct regional benefit - \$1,056,000.

Additional employment due to increased port activity is calculated from the following parameters:

a. regional direct benefits (from above)

b. earnings to gross output ratio; and,

c. earnings to employment ratio.

The earnings-to-gross-output ratio indicates the percentage of labor costs in the total value of output. These ratios were calculated from the following equation: *

$$e_j = \frac{1}{M_j}(E_T) + (1 - \frac{1}{M_j}) E$$

where

e_j is the earnings-to-gross-output ratio for region j for the transportation sector

M_j is the respending multiplier for region j

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* This methodology is described in the documentation for the BEA multipliers (see reference 5 in Appendix B of this report).

E_T is the national earnings-to-gross-output ratio for the transportation sector

E is the national earnings-to-gross-output ratio.

The earnings-to-employment ratio shows the approximate annual salary for an individual in the transportation sector. Earnings-to-employment ratios were calculated from earnings and employment data for various years as reported in Volume 2 of the OBERS projections.** Since a review of historical data showed that these ratios were time-dependent, regression analysis was used to fit an equation to the data. The best fit was an exponential equation of the form:

where $y = ae^{bx}$

y is the earnings-to-employment ratio in $000 per employee

a is the base value

b is the slope of the curve, and

x is the year (1900 is year 0, 1910 is year 10, etc.).

Values for the earnings-to-employment regression co-efficients and the earnings-to-gross-output ratios are given in Table 21.

** Volume 2, OBERS Projections Regional Economic Activity in the United States (1972).

Additional employment for the regional benefits identified earlier in the example is as follows:

TABLE 21

Values for Employment Analysis

BEA Region	Earnings-to-Employment Regression Coefficients $y = 1000\ ae^{bx}$ x = year y = earnings-to-employment ratio Base Value(a)	Slope (b)	Employment to Gross Output Ratios
7	1.7644	.0263	.3053
8	2.0547	.0256	.3055
9	3.3140	.0232	.3048
10	1.1993	.0283	.3055
68	1.5181	.0272	.3046
70	.7509	.0314	.3051
71	1.2254	.0284	.3046
72	1.2859	.0280	.3057
73	.5155	.0338	.3053
74	.4396	.0348	.3055
76	1.1900	.0285	.3054
77	2.9116	.0238	.3042
84	2.8762	.0238	.3049
85	.5204	.0337	.3054
87	.4534	.0349	.3056

Sources: Appendix C, Regional Multipliers
Volume 2, OBERS Projections

a. direct regional benefit - $1,056,000;

b. earnings to gross output ratio - .3046;

c. total additional earnings - $322,000;

d. earnings to employment ratio - $15,788 per employee*; and

e. total increase in port employment - 20 positions.

The next section describes the results of the benefits calculation.

Analysis of Results

Table 22 shows, by commodity type, the additional tonnage, port benefits and savings generated by season extension.** Summaries of direct regional benefits, total benefits and savings, and additional employment are given in Table 23.

It should be noted that Tables 22 and 23 show the aggregate number of port jobs that would be added as a result of navigation season extension. Although the percentage mix of port jobs added would vary somewhat from port to port (depending on the type of cargo handled), the overall, average percent breakdown of port jobs added for each of the harbors listed in Table 24 would be as follows:

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* Calculated for 1990 and BEA 71 (Detroit) as:
(1000 X 1.2254) X e (.0284 X 90) = $15,788 per employee
(Note: e is a logarithmic constant which equals 2.71828.)

** Based on year round season extension operation on the upper four lakes and 11 month operation of the St. Lawrence Seaway.

50% = Longshoremen, stevedores and terminal operators.

20% = Merchant seamen.

15% = Ship and equipment (e.g., loading and unloading equipment) repair personnel.

10% = Freight forwarder, agents, and steamship company owners, representatives and personnel.

5% = Other (e.g., pilot and port administrators).

Summary

Direct benefits are those generated directly by the movement of cargo through a port. These initial revenue funds are respent within the regional economy for other goods several times. Regional multipliers measure the respending of initial benefits by taking into account:

a. interconnections between industries in the region;

b. implications of increased regional household income; and,

c. resulting household consumption expenditures in the region.

The benefits calculations were divided into three categories: (1) direct economic benefits (due to port activity); (2) other economic benefits (due to multiplier effect); and (3) additional employment.

The port jobs added as a result of navigation season extension include: longshoremen, stevedores, seamen, repair personnel, freight agents, ship pilots, and port administrators.

This study has pointed out the benefits of season extension for regional Great Lakes economies. In order to place the results in a proper perspective, the following issues were addressed in this section:

TABLE 22

SUMMARY OF EXTENDED SEASON DIVERTED TONNAGE, AND INITIAL PORT BENEFITS DUE TO SEASON EXTENSION
(In thousand dollars and thousand short tons)

Commodity Total	YEAR					
	1987	1990	1995	2000	2020	2040
			TONS			
Diverted Tonnage*						
Grain*	1610	2852	4123	4311	5191	5471
Coal*	1139	1999	5266	10657	19895	20332
Iron Ore	2362	3874	11408	27095	55025	55226
General Cargo*	864	1737	2457	2457	2457	2457
Total Diverted Tonnage*	5975	10462	23254	44520	82568	83486
			DOLLARS			
Initial Port Benefits**						
Grain**	$8359	$14863	$21358	$22328	$26892	$28360
Coal**	1661	2907	8247	17170	32479	33225
Iron Ore**	1476	2381	7348	17861	36582	36713
General Cargo**	35657	71654	101327	101327	101327	101327
Total Initial Port Benefit**	47153	91805	138280	158686	197280	199625

NOTE: Reflects 12-month operation of upper four lakes, 10-month operation of SLS, and 24 hour operation of all locks.

* For domestic movements, includes diverted tons at both U.S. port of origin and U.S. port of destination. For overseas movements, includes only diverted tons at U.S. port of origin or destination.

** For each commodity, equals diverted tonnage times appropriate benefit factor.

TABLE 23

TOTAL U.S. PORT AND REGIONAL BENEFITS, AND ADDED EMPLOYMENT-SEASON EXTENSION
(In thousand dollars and actual number of jobs)
Bureau of Economic Analysis Multipliers

Commodity Total	YEAR 1987	1990	1995	2000	2020	2040
Grain*	20172	35986	51578	53926	65037	68655
Coal*	4057	7141	19569	40079	75443	77176
Iron Ore*	3624	5972	17848	42845	87218	87529
General Cargo*	99125	199010	281295	281295	281295	281295
Total Initial & Multiplier Regional Benefits	126978	248091	370290	418145	508993	514655
Grains**	356	578	710	634	405	230
Coal**	68	116	287	518	519	276
Iron Ore**	52	84	251	542	597	312
General Cargo**	1328	2484	3080	2697	1586	933
Total added port jobs**,+,++	1804	3262	4328	4391	3107	1751

NOTE: Reflects 12-month operation of upper four lakes, 10-month operation SLS, and 24 hour operation of all locks.

* For each commodity, equals direct port benefits (from Table 22) times appropriate regional multipliers.
** For each commodity, equals conversion of direct regional benefits into additional port jobs using appropriate earnings to gross output ratios and earnings to employment ratios.
\+ After 2010, benefits and savings increase at a very slow rate because the system is near full capacity. Earnings per new employee escalate faster than benefits so that additional employment decreases.
++ To allow for more hours worked by current employees under the season extension program, the number of jobs resulting from total regional benefits was reduced 20%.

TABLE 24

Total Port and Regional Benefits and Added Port Jobs
By Major Port Area and By State
(In thousand of dollars and actual number of jobs)

PORT	1987 Reg. Benefits	1987 Jobs	1990 Reg. Benefits	1990 Jobs	1995 Reg. Benefits	1995 Jobs	2000 Reg. Benefits	2000 Jobs	2020 Reg. Benefits	2020 Jobs	2040 Reg. Benefits	2040 Jobs
Two Harbors, MN	237	5	350	8	1,490	28	4,023	65	8,576	69	8,576	34
Duluth, MN	5,552	142	9,772	226	17,382	339	25,920	424	41,963	342	42,615	172
Taconite, MN	253	5	371	8	1,619	30	4,343	69	9,117	73	9,117	35
Silver Bay, MN	249	5	366	8	1,606	29	4,307	69	9,057	72	9,057	35
MINNESOTA TOTAL	6,291	157	10,859	250	22,097	426	38,593	627	68,713	556	69,365	276
Superior, WI	5,124	131	9,021	209	16,046	313	23,927	392	38,734	316	39,337	159
Ashland, WI	12	0	16	0	116	1	284	4	481	3	481	1
Green Bay, WI	319	7	357	8	726	13	837	12	1,342	10	1,972	8
Milwaukee, WI	5,682	59	11,088	109	15,792	139	16,242	126	18,486	89	19,209	57
Port Washington, WI	0	0	0	0	0	0	0	0	0	0	0	0
WISCONSIN TOTAL	11,138	197	20,482	326	32,680	466	41,290	534	59,043	418	60,999	225
Indiana Harbor, IN	1,161	11	2,385	22	3,884	33	5,534	42	8,105	37	8,105	22
Burns Harbor, IN	892	8	1,886	16	2,891	24	3,588	27	4,747	21	4,747	13
Gary, IN	242	2	517	4	1,053	8	2,155	16	3,900	18	3,900	11
INDIANA TOTAL	2,295	21	4,788	42	7,828	65	11,277	85	16,752	76	16,752	46
Calumet, IL	41,188	432	79,589	779	110,747	962	112,118	865	115,238	551	115,801	341
ILLINOIS TOTAL	41,188	432	79,589	779	110,747	962	112,118	865	115,238	551	115,801	341

TABLE 24 (Cont.)

Total Port and Regional Benefits and Added Port Jobs
By Major Port Area and By State
(In thousand of dollars and actual number of jobs)

PORT	1987 Reg. Benefits	1987 Jobs	1990 Reg. Benefits	1990 Jobs	1995 Reg. Benefits	1995 Jobs	2000 Reg. Benefits	2000 Jobs	2020 Reg. Benefits	2020 Jobs	2040 Reg. Benefits	2040 Jobs
Presque Is., MI	81	0	110	1	440	5	1,170	12	2,482	16	2,482	8
Marquette, MI	84	1	93	1	518	9	1,217	19	2,187	17	2,187	8
Escanaba, MI	265	5	337	6	611	9	689	9	1,052	8	1,492	5
Ludington, MI	29	0	88	1	148	2	209	3	419	3	481	1
Alpena, MI	0	0	0	0	8	0	35	0	60	0	60	0
Saginaw, MI	273	4	384	5	411	4	411	4	411	2	411	0
St. Clair, MI	91	0	205	2	494	6	1,064	12	1,790	11	1,790	6
Detroit, MI	31,315	523	64,819	999	93,199	1,246	94,893	1,101	97,628	640	97,882	362
Monroe, MI	90	1	194	3	476	7	1,030	14	1,732	12	1,732	6
MICHIGAN TOTAL	32,228	534	66,203	1,018	96,305	1,288	100,718	1,174	107,761	709	108,517	396
Toledo, OH	4,014	83	7,777	147	11,524	186	12,891	178	15,391	112	15,669	60
Sandusky, OH	639	9	1,153	16	1,816	21	2,358	24	3,198	19	3,340	11
Huron, OH	57	0	81	0	274	3	644	6	1,349	8	1,354	4
Lorain, OH	127	1	195	2	589	6	1,313	13	2,695	16	2,710	9
Cleveland, OH	16,251	243	33,272	460	48,221	582	50,043	527	56,842	346	56,940	199
Ashtabula, OH	668	9	1,174	15	2,074	23	3,084	30	5,129	30	5,260	17
Conneaut, OH	769	10	1,340	16	2,621	30	4,403	45	7,621	45	7,757	26
OHIO TOTAL	22,525	355	44,992	656	67,119	851	74,736	823	92,225	576	93,030	326
Buffalo, NY TOTAL	11,314	108	21,151	191	33,514	270	39,413	283	49,261	221	50,191	141
GREAT LAKES REGION TOTAL	126,979	1,804	248,091	3,262	370,290	4,328	418,145	4,391	508,993	3,107	514,655	1,751

a. validity of direct benefit factors; and,

b. recommended regional multipliers.

Validity of Direct Benefit Factors

The direct benefit factors for various cargo and port combinations are estimates. These estimates are based on previous port studies performed at different points in time, or are based on extrapolating limited known benefits to all ports in the system. They are measures of constantly changing factors at a specific point in time.

As an aid in identifying the importance of various ports and commodity movements, Table 25 shows 1972 cargo movements and the percentage of each movement to the GL/SLS system movement of the commodity.

Recommended Regional Multipliers

a. BEA regions are composed of a Standard Metropolitan Statistical Area (SMSA) or business center and surrounding counties that are economically tied to the center, grouping place of work and place of residence and therefore defining a homogeneous economic entity.

b. BEA multipliers are updated regularly and publicly supplied.

c. The BEA methodology provides an explicit analytical relationship between changes in output, earnings, and employment.

TABLE 25

1972 Year Cargo Movements by Commodity Types
(In units of 1,000 short tons and percentages of total commodity movement)

	Grain		Coal		Iron Ore		General Cargo	
	Tons	%Total	Tons	%Total	Tons	%Total	Tons	%Total
Calumet	1,728	18.1	282	1.9	4,440	3.6	2,582	37.1
Gary	-	-	-	-	6,282	5.0	-	-
Indiana Harbor	-	-	-	-	6,282	5.0	62	.9
Burns Harbor	-	-	-	-	4,440	3.6	132	1.9
Milwaukee	975	10.2	-	-	-	-	458	6.6
Saginaw	73	.8	-	-	-	-	-	-
Alpena	-	-	-	-	20	0.0	-	-
Green Bay	-	-	0	0.0	-	-	-	-
Ludington	17	.2	-	-	-	-	-	-
St. Clair	-	-	0	0.0	-	-	-	-
Detroit	115	1.2	0	0.0	7,001	5.6	2,190	31.5
Toledo	786	8.2	4,230	28.6	2,927	2.3	519	7.4
Sandusky	-	-	2,986	20.1	-	-	-	-
Huron	-	-	-	-	2,927	2.3	-	-
Lorain	-	-	-	-	2,917	2.3	-	-
Monroe	-	-	0	0.0	-	-	-	-
Cleveland	30	.3	10	0.1	12,885	10.3	583	8.4
Ashtabula	-	-	2,978	20.1	4,831	3.9	-	-
Conneaut	-	-	2,978	20.1	8,377	6.7	-	-
Buffalo	1,381	14.5	1	0.0	3,712	3.0	24	.3
Oswego	-	-	-	-	-	-	0	0.0
Rochester	-	-	-	-	-	-	11	.2
Two Harbors	-	-	-	-	13,347	10.7	-	-
Duluth	4,442	46.5	168	1.1	14,429	11.6	397	5.7
Presque Isle	-	-	-	-	3,389	2.7	-	-
Marquette	-	-	569	3.9	-	-	-	-
Taconite	-	-	166	1.1	13,347	10.7	-	-
Silver Bay	-	-	166	1.1	13,347	10.7	-	-
Ashland	-	-	166	1.1	-	-	-	-
Escanaba	-	-	0	0.0	-	-	-	-
Other Sault	-	-	117	.8	-	-	-	-
TOTALS	9,547	100.0	14,799	100.0	124,910	100.0	6,958	100.0

SOURCE: U.S. Army Corps of Engineers Computer Models.

INTERMODAL IMPACT ANALYSIS

This analysis utilizes the results presented in the study titled, Intermodal Impacts of Great Lakes-St. Lawrence Seaway System Season Extension, prepared for the U.S. Army Corps of Engineers by Tera, Inc., Arlington, Virginia, July 16, 1979.

The intermodal impact study area incorporates 19 states and the water transportation corridor formed by the Great Lakes/St. Lawrence Seaway. Certain ports were specifically identified in the data base. These same ports and the 19 state area were used to identify the rail lines potentially affected by season extension.

The intermodal impact analysis used as primary impacts the results of commodity flow projections for two scenarios. The first scenario is the base case in which no change in the historical shipping season is assumed. The second scenario assumes that the upper four Great Lakes are kept open to navigation all year and the St. Lawrence Seaway and Welland Canal connecting Lake Erie and Ontario are kept open to shipping eleven months of the year. This scenario is consistent with proposed plan number 6 shown in Table 14.

Study Objectives

The net gain to the nation in transportation rate savings can only be accomplished if some traffic is diverted from more costly modes to the Great Lakes. The purpose and scope of this assessment is to go beyond the benefit evaluation of net gains to shippers resulting from the season extension, and attempt to evaluate the impact that the project is likely to have on those modes from which this traffic is diverted. The total loss of revenue could, potentially, seriously affect these modes financially. Specific objectives of the intermodal assessment were to:

a. calculate changes in revenue to each transportation mode affected by the season extension;

b. evaluate the consequences of these changes in revenue to each mode in terms of financial performance; and,

c. estimate the secondary (multiplier) consequences these changes in revenue flows are likely to have upon each state and the Great Lakes region as a whole.

Direct Impacts on Net Revenue Shifts

Net Revenue Shifts

Table 26 shows the total gains and losses experienced by each mode which culminate in net revenue gains or losses for the rail, truck and barge modes. Table 26 also shows revenue gains and losses for Great Lake carriers as well. This will be developed in more detail by mode of transportation below.

Modal Impacts

Four transportation modes are delineated and analyzed: rail, truck, barge, and Great Lakes marine. For each origin-destination commodity movement projected, a mode and rate is designated for overland line haul links and for water links. Figure 4 shows the route and link structure analyzed. Due to season extension, traffic is assumed to shift to a Great Lakes route from an alternate route. Because of this shift, overland line haul transportation shifts from a long distance complete origin destination movement or a long distance movement (to an ocean port) to a shorter distance movement (to a Great Lakes port). The rate specified for the short-haul to the Great Lakes is less than the rate for the longer haul overland movement. This results in a savings in line haul charges to shippers and a revenue loss to carriers.

TABLE 26

IMPACTS ON MODAL REVENUES FROM

SEASON EXTENSION*

($ Thousand)

Mode: Data	1990	2000	2010	2020	2030	2040
Rail:						
Revenue Gained	29,509	128,348	240,720	244,460	251,161	257,881
Revenue Lost	-120,880	-446,561	-807,940	-816,152	-830,084	-844,631
Net Revenue	- 91,364	-318,144	-567,143	-517,110	-578,840	-586,664
% of Base Case	-2.6	-6.3	-8.0	-6.0	-4.6	-3.4
Truck:						
Revenue Gained	21,513	29,222	30,957	31,620	31,482	31,120
Revenue Lost	-28,591	-38,709	-43,005	-46,486	-49,478	-52,518
Net Revenue	- 7,078	- 9,487	-12,047	-14,866	-17,995	-21,397
% of Base Case	-1.6	-1.7	-1.8	-2.0	-2.1	-2.2
Barge: **,+						
Revenue Gained	721	2,195	2,719	2,974	2,932	2,650
Revenue Lost	-1,047	-1,826	-2,223	-2,391	-2,207	-1,881
Net Revenue	- 326	369	496	583	725	769
% of Base Case	-.1	.1	.1	.1	.1	.1
G.L. Domestic:						
Revenue Gained	11,896	68,792	136,711	138,135	139,963	142,110
Revenue Lost	0	0	0	0	0	0
Net Revenue	11,896	68,792	136,711	138,135	139,963	142,110
% of Base Case	2.6	13.8	26.0	24.9	23.9	22.8
G.L. Canada:						
Revenue Gained	4,038	10,511	16,859	18,121	19,272	19,832
Revenue Lost	-93	-217	-277	-365	-401	-537
Net Revenue	3,945	10,294	16,582	17,756	18,871	19,295
% of Base Case	2.4	5.9	8.9	8.2	7.2	5.6
G.L. Overseas:						
Revenue Gained	117,050	172,610	201,967	232,209	265,168	301,304
Revenue Lost	3,097	10,478	12,957	14,429	15,027	15,256
Net Revenue	113,953	162,132	189,010	217,880	250,141	286,048
% of Base Case	14.0	16.9	16.3	15.6	14.5	13.1

* All revenue shifts and impacts were based upon Proposed Plan #6.

** Base Year data not available; a base year revenue of $210,750,000 was assumed for impact evaluation purposes (see main report for details).

+ Tentative net revenue impact on barges in 1990 was the result of a program error in modifying the Logistics Price File for winter cost penalty factors. The error will be corrected in any future work.

The net revenue and tonnage change is itemized by summing the gains and the losses separately. A gain in revenues and tonnage will accrue to carriers operating on the short-haul routes to or from the Great Lakes ports as a result of season extension. Those carriers who operate on the long-haul alternate routes will typically lose revenues and tonnage. The net of all tonnage gains and losses among the overland modes (truck, rail and barge) is zero, because all movements originate at inland points, thereby requiring overland transportation. The sum of both gains and losses on the Great Lakes is equal to the sum of the gains or losses of the overland modes.*

For purposes of this study conservative assumptions were made. As a consequence, this analysis tends to overstate the negative modal impacts (except to truck) of the Great Lakes/St. Lawrence Season Extension project. Recognizing this fact, the intermodal impact evaluation provide valuable first estimates of direct and indirect impacts to other transportation modes, ports, and states.

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* Three features of the input data tapes used for this impact analysis should be noted.

1. As stated in footnote of Table 26, the barge mode shows a small negative impact in 1990.

2. The negative impacts tend to be overestimated for rail and underestimated for truck, due to the character of the general cargo data file.

3. Stevedore charges are not segregated in the published ocean shipping rate, therefore the port revenue impacts are understated. This results in reducing the positive impacts to ocean and Great Lakes ports and negative impacts to ocean ports. The Regional Economic Analysis shows revenue impacts at the port level from a proprietary data file of stevedoring charges.

Railroads

The railroads clearly show the largest impacts resulting from season extension. For coal and iron ore, the railroad is the only competing or supporting mode assumed. Therefore, the only shifts that occur are from long-haul competing railroads to short-haul supporting railroads. This results in a revenue loss to the railroads as a whole, although to the extent that different firms are impacted some railroad companies may gain revenue who handle short-haul supporting traffic. The most significant shift is in iron ore where Great Lakes carriers have traditionally carried the largest share of the cargo. Therefore, any cargo not carried on the Great Lakes due to winter closing would be shifted from the railroads if the season is extended.

Overland movements of grain shift not only from long- to short-haul railroads, but between modes resulting in a net loss of tonnage to the railroads.

Truck

For purposes of this analysis, railroads were assumed to be the overland carrier of general cargo. This resulted in an overstatement of the negative impact on railroads and an understatement on the trucking industry in assessing diversion of general cargo to Great Lakes navigation. This is because trucks would be expected to carry a significant share. Only grain movements show an impact on trucking revenues. Two counteracting effects are found for the trucking industry. On the one hand, due to a shift to short-haul movements, trucks enjoy a net gain in grain tonnage. On the other hand, grain tonnage losses to trucking are in long-haul high revenue movements which are sufficient to overcome tonnage shifts and result in a net loss of revenues to the trucking industry as a whole. However, the gains and the losses will not likely accrue to the same firms.

Barge

Barge revenues also only change in the carriage of grain. However, the overall effect of season extension on the barge industry is negligable.

Great Lakes Marine

The intermodal impact assessment was limited to the evaluation of project induced impacts to the domestic economy. Therefore, revenue shifts to ocean carriers of foreign commerce, whether via a Great Lakes or alternate port has not been evaluated. Domestic versus foreign impacts can be differentiated conceptually from Figure 4. Some observations about balance of trade impacts of potential diversions to foreign flag carriers are provided later in the assessment.

Port Impacts

Port impacts are outlined separately for Great Lakes ports in the Regional Economic Analysis section. Tonnage changes at specific Great Lakes ports are provided as an input to the intermodal assessment. Port changes are given for both Great Lakes ports and ocean ports in the Price Logistics File. Port changes include port fees and storage fees, but do not include stevedoring charges. This resulted in a more conservative estimate of port multipliers relative to other transport modes. The alternate port allocation was developed from data obtained by the U.S. Bureau of the Census from a study of Customs documents.*

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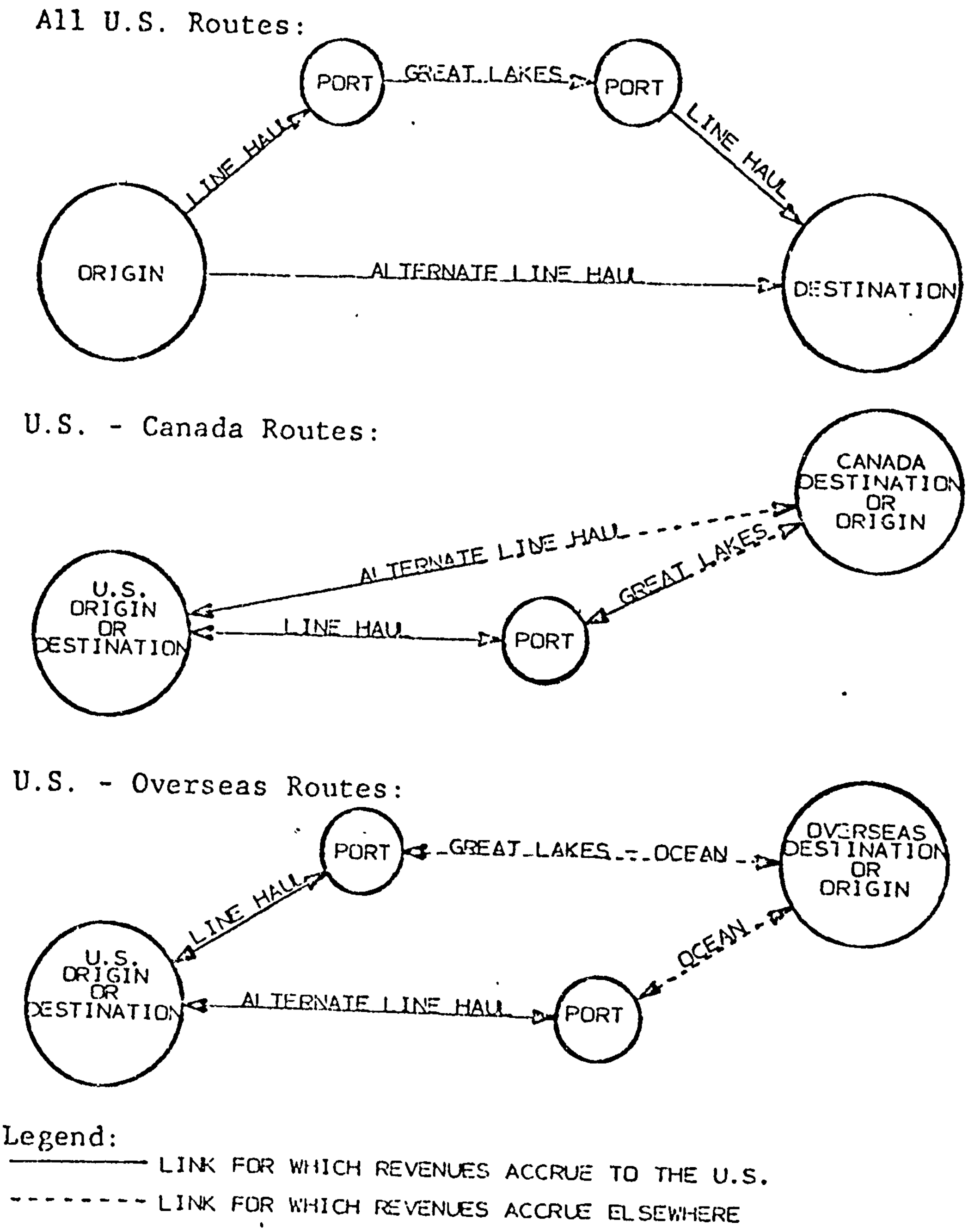
* Bureau of the Census, Domestic and International Transportation of U.S. Foreign Trade: 1976, Public use tape U.S. Department of Commerce, Washington, D.C., 1979.

FIGURE 4

TRANSPORTATION LINKS FOR WHICH REVENUES ARE ASSUMED TO ACCRUE TO THE U.S.



Ports are positively impacted in all Great Lakes states except New York. In New York, positive impacts at the Buffalo port are offset by larger negative impacts at New York City. The net negative impacts on railroads, trucks and barges offset gains to Great Lakes marine carriers and those ports in the Great Lakes states.

Financial Impacts on Firms

Specific financial impacts on any one firm caused by project induced revenue shifts cannot be reasonably predicted. Impacts are, therefore, generalized in the form of composite financial statements for all firms within a particular mode likely to be affected by the proposed project. From these data an analysis was performed to determine the potential affect these net revenue shifts would likely have on the financial performance of each mode.

Selected financial statistics and operating data of each transportation mode serving the Great Lakes region were collected and aggregated to create composite financial profiles. This composite modal profile summarizes the total operating revenues, expenses and incomes of all firms potentially affected by season extension. The net revenue shifts resulting from season extension for each mode are then reflected in the financial performance statistics of the modal composite profile. In this financial analysis, rail impacts are emphasized since this mode is the most significantly affected.

Railroads

Financial performance data for each Class I railroad which constitute the GL/SLS study profile are presented in Table 27. Base year financial data items used to create the composite profile were taken from each firm's income statement and balance sheet for 1977, the last full year for which data are available.

Table 27 shows that the railroads in the composite are, for the most part, not highly profitable. As a result all key performance ratios will be affected by the revenue shifts caused by the season extension program.

Projected Rail Revenue

Total railroad revenues derived from those commodities which are impacted by the proposed season extension (specifically grain, coal, iron ore, and general cargo) were projected and then used as input to the intermodal impact analysis. The 18 railroads which operate in the GL/SLS study area also derive revenue from the transport of other than these four commodities. This non-impacted traffic was assumed to grow over the forecast period at an annual rate of 2.2 percent. This forecasted (constant dollar) rail revenue growth rate through the year 2000 was estimated by the National Transportation Policy Study Commission.* This Congressional Commission's report projected low, medium, and high economic growth scenarios. Medium and high growth scenarios resulted in rail revenue growth rates of 4.4 and 5.9 percent respectively. Use of the commission's low scenario growth rate of 2.2 percent per year was purposely adopted so as to avoid understating the potential impact on the rail carriers from the proposed season extension. This will tend to bias the significance of the season extension negative impacts upon the railroads upward.

A moderate or high growth rate (4.4 and 5.9 percent) in non-diverted traffic would dampen the negative impacts of diverting traffic from the railroad industry to Great Lakes movement.

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* National Transportation Policy Through the Year 2000; National Transportation Policy Study Commission; June 1979.

TABLE 27

FINANCIAL STATISTICS OF SELECTED

CLASS I RAILROADS

	GROSS RAILWAY OPERATING REVENUE	GROSS RAILWAY OPERATING EXPENSE	NET RAILWAY OPERATING REVENUE	OPERATING RATIO(%)	NET RAILWAY OPERATING INCOME	RATE OF RETURN ON INVESTMENT	FIXED CHARGE COVERAGE	MARGIN OF SAFETY	NET WORKING CAPITAL	RETURN ON SHAREHOLDER EQUITY
Atchison, Topeka & Santa Fe	1,349,005	1,105,560	243,445	81.95	80,775	.032	3.74	6.52	80,500	.058
Baltimore & Ohio	762,860	548,298	214,562	71.87	82,971	.054	3.13	10.03	48,121	.11
Bessemer & Lake Erie	84,568	61,249	22,227	73.71	13,096	.07	*	*	16,052	*
Burlington North	1,677,587	1,396,416	281,441	83.23	61,544	.018	2.11	4.04	98,865	.036
Chesapeake & Ohio	622,011	525,988	96,023	84.56	5,744	.003	4.46	9.9	(42,255)	.008
Chicago, Milwaukee, St. Paul**	467,679	497,072	(29,393)	106.28	10,628	.013	*	*	20,216	.024
Chicago & North-western	562,700	458,663	104,037	81.57	16,903	.032	.97	*	(45,146)	.79
Chicago, Rock Island, Pacific**	362,791	308,895	53,896	85.10	(38,463)	(.09)	*	*	(8,085)	(.3441)
Conrail	3,292,389	2,944,588	347,801	89.44	(351,343)	(.11)	*	*	35,327	*
Detroit, Toledo & Ironton	62	47	15	75.61	26	.003	3.24	3.65	(1.5)	.0005
Detroit & Toledo Shoreline	13,184	9,444	3,740	71.63	916	.047	5.82	6.65	1,776	.08
Elgin, Joliet & Eastern	107,544	80,334	27,210	74.70	8,598	.06	11.66	13.5	9,876	*
Illinois Central Gulf	671,871	552,448	119,423	82.23	1,174	.0009	1.13	*	(25,687)	.0016
Louisville & Nashville	764,217	597,048	167,169	78.13	54,873	.036	1.38	3.74	(26,956)	.102
Messabe & Iron Range	46,475	47,309	(564)	101.21	(2,869)	.020	*	*	(4,548)	(.036)
Missouri & Pacific	1,064,028	760,852	303,176	71.51	134,776	.070	4.17	11.97	83,050	.22
Norfolk & Western	1,135,501	826,904	308,597	72.82	127,211	.050	4.39	13.32	180,101	.11
Pittsburgh & Lake Erie	59	55	4	93.95	8	.00002	5.06	14.25	(3.4)	.00003

NOTES: Parenthesis denote negative figures. Dollar figures shown with 000's omitted.

* Not available from source data.

** Line operating under bankruptcy.

Projected Railroad Operating Expenses

Gross operating expenses for future years were generated under the assumption that the operating ratio present in 1977 remains constant. This assumption might bring the bias in the negative impact of season extension downward, as it assumes that rail carriers are able to successfully vary costs with output. Historically, the evidence has shown that as the railroads have lost high value cargo to the trucking industry, and as fuel and labor costs have escalated, the rail operating ratio has edged upward. However, it is not clear what direction this key ratio will take in the future and not all lines in the composite are alike in this regard. Without additional information, the assumption that the operating ratio remains constant at the 1977 base year level is the best that can be justified.

Conrail

The inclusion of the Consolidated Rail Corporation (Conrail) in developing the rail modal profile has a decided impact on the outcome. The relative impact on net income appears to be more serious because Conrail is included in the composite profile. Because Conrail is an important carrier in the region, it would be inappropriate to ignore it. However, because it is much larger than the other railroads, (earning more than 1/4 of the total gross operating revenues of the railroads in the profile), and because its performance has been so volatile in its early years of operation, the results of this impact analysis are very sensitive to Conrail's performance. If Conrail were excluded, for example, the composite profile's net operating income in the base year would be $560,000,000 rather than $210,000,000. Conrail's losses have been particularly large, and thus sharply reduce the composite net operating profile for the railroad industry in the region. On the other hand, the corporation is expected to announce that, for the first time, it has earned a quarterly profit of $22-$27 million for the second quarter

of 1979. If such improvements in Conrail's performance are sustainable, then the key performance ratios may be better than those which appear in Table 27, especially after 1990, as Conrail achieves operating parity with other railroads in the region.

The table reveals a significant negative impact upon net revenue for the railroads under the season extension program relative to the without condition. The impact is forecasted to be the greatest in 2010 when diverted traffic to season extension would reduce net income to the railroads in the Great Lakes region by 23 percent from what they would receive without season extension. It is important to note that this comes as a result of only a 2.1 percent decline in gross revenues to the railroads. This relationship between gross revenues and net revenues is evident throughout the forecasted 50 year project life; a drop in gross revenues by 1 percent, results in (approximately) a 10 percent decline in net revenue. This finding is significant but its significance should be carefully understood and weighed.

The magnified reduction in net revenues that accompanies a smaller reduction in gross revenues for the railroads reflects more on the plight of the rail industry than on season extension. The results shown in Table 28 emphasize the importance of the assumption that the operating costs to revenues ratio will be constant. If operating costs as a proportion of revenues increase with revenue losses, then the negative impact upon net revenues would be even greater. On the other hand, if total traffic and gross revenues increase at a rate greater than the 2.25 percent assumed in the low growth rate scenario, then the negative impacts of diversion of some traffic to season extension is diminished. So too, if the railroads are granted more discretion in managing their costs, the negative impacts of diverted traffic and revenues would be diminished. Thus, the impacts can be better understood in terms of the problems railroads face in managing operating costs, i.e., reducing costs,

TABLE 28

IMPACT OF REVENUE SHIFTS ON

COMPOSITE FINANCIAL PROFILE OF RAILROADS
($ Thousands)

	Base Year	1990	2000	2010	2020	2030	2040
Gross Operating Revenue*	12,985,000	17,340,638	21,661,984	27,060,225	33,803,726	42,227,730	52,751,025
Total Revenue Shift	N/A	-91,364	-318,144	-567,143	-571,110	-578,840	-586,664
Revised Revenue	12,985,000	17,249,274	21,343,840	25,493,082	33,232,616	41,648,890	52,164,361
Gross Operating Expenses**	10,720,000	14,241,001	17,621,475	21,872,689	27,436,848	34,385,324	43,066,897
Net Operating Revenue	2,265,000	3,008,273	3,722,366	4,620,394	5,795,768	7,263,566	9,097,465
Composite Expense Differential+	2,055,000	2,744,321	3,428,215	4,282,539	5,349,762	6,682,941	8,348,352
Net Operating Income	210,000	263,952	294,150	337,855	446,006	580,626	749,112
Net Operating Income w/o Season Extension	210,000	279,886	349,635	436,765	545,608	681,575	851,426
Percentage Revenue Decrease	N/A	.5	1.5	2.1	1.7	1.4	1.1
Percentage Net Income Decrease	N/A	5.7	15.9	22.6	18.3	14.8	12.0

* Assumed to grow at 2.25 percent per annum.
** Assumes a constant operating ratio of 82.56 percent.
+ The composite expense differential represents all taxes payable, net hire of equipment and net joint facility rents. These items are subtracted from gross operating revenue to yield net railway operating income. It is also assumed to grow at 2.25 percent per annum.

when faced with reduced revenues. The response to this problem is not that of deferring on season extension and its efficiency gains to shippers; but on improving the posture of the railroads to more efficiently manage their costs.

Commodity Specific Rail Impacts

For some railroads, a large proportion of their total revenue is derived from the transport of only a few commodities. The diversion of a particular commodity; therefore, may have more significance to some lines than to others. Commodity specific data were not available for all Class I railroads nor for any Class II lines. The following table summarizes the commodity data available for the railroad industry. Specific revenue impacts to any particular firm, however, should not be implied.

Grain: In Table 29, the net grain diversions from railroad to season extension are relatively small, ranging from 1.22 percent to 4.04 percent, the absolute net revenue loss could be potentially significant to certain individual lines. For example, grain accounts for a substantial portion of revenues for five railroads. All these railroads earn more than 10 percent of their operating revenues from grain carriage.

Coal: Total railroad revenues for coal haulage, shown in Table 29, amounted to over $654 million in 1977. The revenue diversion ranges from less than 1 percent in 1990 to 8 percent in 2010. Six rail lines derive a large amount of their revenues from coal. Each of these lines derive more than 20 percent of their revenues from coal. The impact may be most burdensome for two of these railroads, where coal contributes 42 percent and 38 percent, respectively, to their total revenues. In another case, coal comprises only 20 percent of gross operating revenue; but revenues are small and the firm operates totally in the Great Lakes region where the effect would be more pronounced.

TABLE 29

RAILROAD REVENUE IMPACTS
($ in millions)

GRAIN

	Base Year	1990	2000	2010	2020	2030	2040
Total Revenue Base Case	505.72	719.38	1,050.19	1,424.30	1,784.76	2,062.91	2,323.72
Net Revenue Diverted	N/A	-29.05	-46.96	-38.33	-46.29	-32.35	-28.29
% Diverted	N/A	- 4.04	- 3.71	- 2.69	- 2.01	- 1.57	- 1.22

COAL

	Base Year	1990	2000	2010	2020	2030	2040
Total Revenue Base Case	653.92	862.79	1,092.95	1,394.90	1,619.78	1,880.94	2,193.56
Net Revenue Diverted	N/A	- 6.16	-56.49	-112.15	-111.69	-111.19	-110.74
% Diverted	N/A	- 0.71	- 5.17	- 8.04	- 6.90	- 5.91	- 5.05

IRON ORE

	Base Year	1990	2000	2010	2020	2030	2040
Total Revenue Base Case	457.71	555.34	808.32	1,242.27	1,626.83	2,116.36	2,684.13
Net Revenue Diverted	N/A	-23.83	-175.81	-361.56	-359.40	-360.70	-361.99
% Diverted	N/A	- 4.29	-21.75	-29.10	-22.09	-17.04	-13.49

GENERAL CARGO

	Base Year	1990	2000	2010	2020	2030	2040
Total Revenue Base Case	947.60	1,401.07	2,065.18	3,036.90	4,481.17	6,624.97	9,832.94
Net Revenue Diverted	N/A	-32.33	-47.11	-55.29	-64.27	-74.80	-85.84
% Diverted	N/A	- 2.31	- 2.28	- 1.82	- 1.43	- 1.13	- 0.87

Iron Ore: The base year revenues of $457.71 million for iron ore are the smallest for any commodity in the study. Table 29 shows percentage diversions of revenue are large. These range from 4.3 percent to nearly 30 percent by the decade year 2010. However, smaller lines specializing in ore movements presumably carry a disproportionate share of this traffic and would, therefore, be disproportionately affected. Precise commodity revenue data is unavailable for these lines. In some cases, the lines operate as a subsidiary of steel firms. Therefore, the diversion of specific commodity traffic from these carriers may not depend as much upon the availability of an alternative mode at a lower rate, as on the parent company's decision to transport ore on its own railroad or by its own Great Lakes vessels.

General Cargo: General Cargo, which represents several commodities, generated the largest amount of revenues; $947.6 million in 1977. Of this amount, the largest diversions, 2.3 percent, occur in the decade years 1990 and 2000 respectively. This is the smallest percentage impact of any commodity group analyzed as shown in Table 29. Revenue derived from hauling general cargo, however, contributes heavily to the revenues of all rail lines evaluated, ranging from 21 percent to 52 percent of individual carrier receipts. These general cargo impacts to rail are overstated, as mentioned previously.

Truck

Revenue shifts to and away from trucking firms were evaluated only for the movement of grains. Farm produce is carried primarily by exempt for-hire and private motor carriers for which no financial or operating statistics are published. The few regulated common carriers which transport farm products provide no basis against which to measure the magnitude of revenue shifts found in this study. The forecasted total tons of grain carried by all regulated and unregulated trucks in the 1980 pre-season extension year which will originate in the 19 state study area will amount to 33 million tons.

In contrast, the entire United States, Class I common and contract motor carriers of property only carried 1 million tons of grain in 1973. These same regulated carriers transported a total of 561 million tons of all commodities. Grain, therefore, constitutes a very small portion of regulated truck traffic and very little other grain carried in trucks is carried by regulated carriers.

Truck Composite Profile

It is apparent from the data given above, and the fact that agricultural commodities are most significant to exempt for-hire carriers, that grain traffic shifts impact primarily firms engaged in exempt for-hire service. These are firms which are outside of the jurisdiction of the Interstate Commerce Commission. Being unregulated, there is free entry and exit from the industry and a generally competitive pricing structure. It is commonly regarded that this results in lower rates for movement of agricultural commodities.

In addition to regulatory restraint on the carriage on non-agricultural (i.e., non-exempt) commodities by exempt for-hire carriers, specialized equipment requirements further restrict the range of agricultural commodities to be shipped in any one truck. Grain is commonly shipped in open and covered hopper or dry tank trucks not suitable for carriage of other than bulk dry commodities like grains.

The truck grain cargo potential given in the data base is coincident with the total cargo of the affected firms. This is true, however, only if equipment and regulatory restrictions prohibit these truck firms from hauling other than grain.

The impacts will be overstated if the admittedly specialized truck equipment can be used to haul other than bulk products. Firms with larger fleets of many different truck types will be less affected by diversion of grain traffic than firms totally dependent on grain traffic.

Financial Impacts on Truck

Table 30 outlines the impact of season extension on the trucking industry in the area. At a maximum, the percent revenue diversion from the industry or mode given in the table is equal to the percent revenue diversion from the composite of all firms in the industry which transport grain. Due to aggregations of data in the Logistics Price File, not all land feeder modes were specified.

The absence of modal specification from land movement of general cargoes has the effect of shifting traffic on general cargo movements away from truck. The analysis of railroad financial well-being is the more sensitive issue, and was maximized by the study assumptions.

Inland Barge Transportation

Although there are some 1,800 individual inland towing companies, it is estimated by industry sources and associations that the vast majority of inland waterborne grain is carried by less than twenty firms. It is not possible to make more exact estimates since all waterborne grain is exempt from Interstate Commerce Commission (ICC) regulation. In fact, less than 10 percent of all waterborne commerce is regulated. As a consequence, very little information exists as to which towing companies move these commodities, and even less as to the financial status of these firms.

TABLE 30

TRUCK TONNAGE AND
REVENUE SHIFTS DUE TO SEASON EXTENSION*
(dollars and tons in thousands)

	Gains	Losses	Net	Percent of 2/2/1
Revenues:				
1990	21,513	-28,591	- 7,078	-1.6
2000	29,222	-38,709	- 9,487	-1.6
2010	30,957	-43,005	-12,047	-1.8
2020	31,620	-46,487	-14,866	-1.9
2030	31,482	-49,478	-17,995	-2.1
2040	31,120	-52,518	-21,397	-2.2
Tons:				
1990	1,772	-1,029	742	1.9
2000	2,458	-1,549	909	2.1
2010	2,706	-1,839	866	1.8
2020	2,850	-2,067	782	1.5
2030	2,914	-2,251	663	1.2
2040	2,955	-2,417	537	0.9

*Revenues and tonnages reported are for grain traffic only. General cargo is reflected in rail impacts. Coal and iron ore movement by truck is too small to report.

In contrast to other commodity movements, it is projected there will be a diversion of grain movement from Great Lakes to the inland waterways. This is the result of the increase in Great Lakes navigation rates to foreign grain carriers forecasted to occur as a result of Season Extension. The actual diverted grain traffic is very small. The net tonnage impact ranges from only 18,000 tons in the year 2000 to a high of +45,000 tons in 2040. This compares with a total of 26,347,058 tons of grain which moved by inland barge transportation in 1975. Even when compared with the hignest diverted amount, a net of less than 0.02 percent of inland waterborne grain traffic is affected by season extension. Given that the total waterborne commerce in 1975 was 63,080,102 tons, the impact is even less significant.

Financial Profiles of Inland Barge Carriers

Financial data is not available on those barge carriers which transport grain on inland waterways. In order to estimate the magnitude of impact which revenue shifts may cause to inland waterway operators, a financial profile had to be constructed from available information.

The financial data used to construct this profile is taken from data introduced by the Waterways Freight Bureau in November 1978, as support documentation in reply to the Interstate Commerce Commission, Suspension Board Case Number 68652.

This documentation contains operating revenues for the year 1977 (Specific dates of the revenue year indicated in the source). These revenues are reported for seven inland barge firms, four of which are also large grain common carriers operating in the 19 state Great Lakes region.

Financial Impacts to Barge

Table 31 represents the composite profile of the barge firms. The profile shows a net income of $20 million on total revenues of $210 million; this represents a return on revenue of 9.6 percent. The operating ratio, the percentage of revenue consumed by operating expenses, equals 90.4 percent.

TABLE 31
COMPOSITE FINANCIAL PROFILE
INLAND BARGE OPERATORS
($ in thousands)
1977 DATA

	Total	Mean
Operating Revenues	$210,750	$30,107
Operating Expenses		
Towboat	112,500	16,100
Barge	31,800	4,500
Port	21,700	3,100
Cargo	5,000	714
General & Admin	19,000	2,814
Total Operating Expenses	190,700	27,243
Net Operating Income	20,050	2,860
Operating Ratio	90.4	

All revenue shifts to the barge mode are positive, as shown below in Table 32.

It is not possible to directly compare these revenue gains to the composite profile since grain is only one of the commodities carried by these firms, and very likely more than just these firms would be involved in the transport of this diverted commerce. Diverted revenues are very small, however, and increases amount to less than 1 percent of the total base year grain revenues. The impact on total revenues, would therefore, be insignificant.

TABLE 32

NET BARGE REVENUE IMPACTS

($ in millions)

GRAIN

	Base Year	1990	2000	2010	2020	2030	2040
Total Revenue Base Case	205.04	307.23	496.46	738.15	973.31	1,146.73	1,289.32
Net Revenue Diverted	N/A	-	.37	.50	.58	.73	.77
% Diverted	N/A	-	.074	.067	.060	.063	.060

Great Lakes Ports

Many Great Lakes ports are projected to experience a gain in traffic and revenues as a result of extending the shipping season on the GL/SLS System. Some of this gain in traffic, that related to foreign commerce, will be had at the expense of ocean ports. Revenue changes at ports were based on tonnage projections under two scenarios and port charges. These have been briefly included in the state gross output analysis in this modal impact analysis but are discussed in more detail in the section on Regional Economic Analysis, which deals entirely with revenue impacts at Great Lakes ports and surrounding BEAs.

Ocean Ports

Ocean ports impacts were analyzed for six coastal port ranges. The multiplier used to compute changes in Gross Regional Output for regions affected by ports in each port range is a weighted average of the BEA regional multipliers appropriate to the port range. Each major port in the port range is assigned a multiplier equal to the BEA economic area multiplier in which the port lies. The average multiplier for all ports in the port range is obtained using annual tonnage as the weighting factor. Ocean port range multipliers are shown in Table 33 along with the revenue change and Gross Regional Output change computed with these multipliers.

Gross State Output Impacts for Modes and Ports

The Bureau of Labor Statistics (BLS), as part of its Economic Growth Model, has developed an input/output interindustry model of the United States disaggregated into 162 sectors. Of immediate interest is the fact that the transportation sector is disaggregated into water, rail, and truck transport industries. Unfortunately, only a co-efficient matrix showing the direct requirements of the modes was available. In addition, the BLS reports national, rather than regional, interindustry relationships. Statewide transport modal specific gross output multipliers were developed through combining information available from both BEA and BLS.

As can be observed from Table 34, water multipliers tend to be larger than those of rail or truck. This is primarily due to differences in the <u>direct</u> investment component found in the BLS multipliers. The BLS <u>direct</u> requirement coefficients for rail, truck and water transport are: .386764, .372257, and .628951, respectively. Other things equal, the multipliers for the water mode will be larger than those for rail or truck. On the other hand, the

TABLE 33

REVENUE AND GROSS REGIONAL OUTPUT IMPACTS ON COASTAL PORT AREAS
($ in thousands)

Coastal Port Area: Year	Revenue Change at Ports due to Season Extension	Revenue Multiplier	Gross Regional Output Impact	Coastal Port Area: Year	Revenue Change at Ports due to Season Extension	Revenue Multiplier	Gross Regional Output Impact
North Atlantic:		2.9014		Gulf:		2.5284	
1990	-1,648		- 4,782	1990	- 3,142		- 7,944
2000	-2,382		- 6,926	2000	-3,361		- 8,493
2010	-2,800		- 8,124	2010	-3,372		-8,526
2020	-3,252		- 9,435	2020	-3,296		-8,334
2030	-3,787		-10,988	2030	-3,152		-7,979
2040	-4,335		12,578	2040	-3,091		-7,815
Mid-Atlantic:		2.5713		California:		2.8437	
1990	-2,427		- 6,241	1990	-352		-1,001
2000	-3,428		- 8,814	2000	-551		-1,567
2010	-4,039		-10,385	2010	-628		-1,787
2020	-4,713		-12,119	2020	-675		-1,920
2030	-5,507		-14,160	2030	-699		-9,938
2040	-6,335		-16,289	2040	-714		-2,030
South Atlantic:		2.1763		Pacific-Northwest:		2.4557	
1990	- 66		-144	1990	-389		- 955
2000	- 90		-196	2000	-548		-1,346
2010	-107		-233	2010	-549		-1,348
2020	-122		-266	2020	-524		-1,287
2030	-144		-313	2030	-491		-1,236
2040	-164		-357	2040	-451		-1,108

NOTE: Revenue changes are computed on the basis of storage and handling fees given in the Price Logistics File. Stevedoring costs were subsumed into the ocean freight rate and are not included in these figures. Ocean freight rates ranged for $100-$400 a long-ton. For containerized cargo the stevedoring cost ranged from $12-$26 per long-ton, with a mean weighted average of $18 per long-ton. For bread-bulk cargo these charges ranged from $5-$35 with a weighted mean average of $22 per ton.

TABLE 34

STATE MULTIPLIERS FOR
MODES AND PORTS
(1990)

STATE	RAIL	TRUCK	WATER	PORT
NY	2.1920	2.2239	2.6794	2.3017
PA	2.1378	2.1681	2.6102	2.2485
OH	1.9907	2.0118	2.4153	2.0986
MI	2.1184	2.1495	2.5985	2.2243
IN	2.0217	2.0416	2.4530	2.1276
IL	1.9598	1.9821	2.3775	2.0695
WI	1.9327	1.9486	2.3335	2.0357
MN	1.9830	2.0044	2.4089	2.0937
ND	1.6153	1.6138	1.9246	1.7211
SD	1.6347	1.6361	1.9498	1.7405
NT	1.7787	1.7886	2.1385	1.8857
IA	1.7353	1.7403	2.0756	1.8373
WY	1.9598	1.9226	2.3020	2.0114
CO	2.0101	2.0304	2.4404	2.1179
MO	1.9985	2.0193	2.4215	2.1033
NE	1.7430	1.7514	2.0882	1.8470
KS	1.7353	1.7403	2.0819	1.8422
WV	2.0604	2.0862	2.5033	2.1662
KY	1.9404	1.9560	2.3461	2.0454
ME	1.9249	1.9449	2.3335	2.1388
MA	2.4009	2.4471	2.9499	2.7927
RI	2.4009	2.4471	2.9499	2.7927
CT	2.2539	2.2908	2.7549	2.7290
DE	2.2113	2.2462	2.704	2.5937
MD	2.2113	2.2462	2.7046	2.5937
VA	2.0681	2.0937	2.5159	2.1942
NC	1.9985	2.0193	2.4278	1.8887
SC	1.9636	1.9828	2.3775	2.1119
GA	1.9404	1.9597	2.3524	2.1156
FL	2.0797	2.1048	2.5285	2.5263
AL	1.9946	2.0156	2.4215	2.2402
MS	1.8514	1.8630	2.2328	2.2402
LA	1.9714	1.9895	2.3001	2.5785
TX	1.8978	1.9151	2.2957	2.4363
CA	2.0488	2.0714	2.4907	2.8894
OR	2.0565	2.0525	2.5033	1.8233
WA	1.9559	1.9746	2.3712	2.5284

induced element of the water transport multiplier will be less than that of rail or truck because it is much less labor intensive than those modes. Therefore, the process of estimating the induced components of the rail, truck and water multipliers by weighting a proportion of the indirect impacts by the relative earnings/output ratios, serves to reduce the size of the water multipliers in comparison to the rail and truck multipliers. Nevertheless, this does not completely offset the effects due to the differences in size of direct requirements and as a result water multipliers remain somewhat larger than those of truck or rail.

State level gross output impacts, the sum of direct and indirect impacts, are presented in Table 35 along with the direct impacts for modes and ports. Table 35 represents a summation of the impacts for all states identified in the study. A more detailed discussion of regional impacts is given in the section devoted to the subject.

Ancillary Issues

Energy

The recent change in energy costs precipitated by the actions of the OPEC cartel, but also reflective of a growing scarcity of once readily available fuels, will also have an effect on comparative modal financial and operating performance. Changing energy prices

TABLE 35

SUMMARY OF NET REVENUE IMPACT AND GROSS STATE OUTPUT IMPACT OF SEASON EXTENSION
($ Thousand)

Mode	YEAR 1990	2000	2010	2020	2030	2040
Rail	- 91,364	-318,144	-567,143	-571,110	-578,840	-586,664
Truck	- 7,078	- 9,487	- 12,047	- 14,866	- 17,995	- 21,397
Barge*	-326	+369	+496	+583	+725	+769
G.L. Marine**	+ 11,896	+ 68,792	+136,711	+138,135	+139,963	+142,110
G.L. Ports+	+ 8,414	+ 27,322	+ 48,361	+ 48,964	+ 49,633	+ 50,370
Ocean Ports+	- 7,831	- 10,087	- 11,168	- 12,202	- 13,336	- 14,584
TOTAL	- 86,289	-241,235	-404,790	-410,496	-419,850	-429,387
Sum of Impacts to Gross State Outputs	-166,210	-438,666	-723,458	-730,314	-750,328	-770,188

* Negative net revenue impact on barges in 1990 was the result of a program error in modifying the Logistics Price File for winter cost penalty factors. The error will be corrected in future work.

** Includes net change in domestic revenues only. Modal revenues for overseas trade and one-half of revenues on Canadian trade not included.

\+ Stevedoring costs are not separated in the Federal Maritime Commission files of ocean tariffs, and therefore are not utilized in this analysis. Accordingly, the dollar impacts on Great Lakes and Ocean Ports are understated.

will impact the fortunes of the competitive modes in several ways. First, changing fuel costs will result in higher rates and since the energy intensity of the modes differs, competitive positions will be affected. Water carriage is usually the most energy efficient mode of transport in terms of BTU's per ton-mile, but rail may be more efficient if the value of output is taken into consideration. Over a period of time, shippers might choose to rely on different modes to meet their needs due to fuel price induced rate changes and some shippers might change their locations substituting spatial location for transportation. Further, the energy crisis might result in more rapid development of western coal, greatly influencing the future of the nation's railroads and water carriers. The findings presented here make no allowance for such impacts, nor is it possible to evaluate such consequences of a single project, such as the GL/SLS season extension, in isolation.

Balance of Payments

The United States is suffering from a chronic deficit in the balance of payments. Progress toward alleviating the deficit through negotiations with key trading partners will largely be eliminated by rapidly increasing prices for imported oil. Relevant to the present analysis is the fact that the season extension program will likely result in some diversion of traffic and revenues from domestic railroads to foreign-owned ships which predominantly service the Great Lakes in foreign trade. The size and importance of the shift on the balance of payments problem is not part of the present analysis, but is a related issue which will require further consideration in subsequent studies.

Deregulation

Deregulation of railroad and truck transportation is once again a seriously considered policy alternative. The apparent success of relaxed regulation in the air transport industry and the stated

Congressional purpose in the last two major railroad bills to become law have made deregulation a political possibility. The objective of deregulation, probably to be accomplished in stages, is to permit carriers greater flexibility in establishing and abandoning service and to have greater freedom to set prices in response to market forces. Bulk commodities, such as those transported on the GL/SLS, would logically be early candidates for deregulation. It is a matter of controversy just what result free market competition will have on modal shares. Certainly, some adjustment in local dominance of one or another mode could be expected. How these changes will work themselves out is highly speculative.

COMPARATIVE ENERGY ANALYSIS

Study Approach

This analysis utilizes the results presented in the study titled, The Energy Impact of Great Lakes-St. Lawrence Seaway Navigation Season Extension, prepared for the U.S. Army Corps of Engineers by Tera, Inc., Arlington, Virginia, November 15, 1978. The impact of Great Lakes season extension on the consumption of energy in the United States and in the shipment of United States commerce is examined in this study in three elements:

a. changes in energy consumed in line haul freight operations due to changes in the share of the traffic going via Great Lakes carriers, and changes in the Great Lakes fleet mix;

b. changes in energy consumed as a result of reductions in stockpiles of iron ore and coal; and,

c. energy expended by facilities and operations specifically designed to support winter navigation.

These elements constitute the most significant and most readily identifiable effects which season extension on the Great Lakes will have on the consumption of energy.

The greatest portion of energy to be consumed or saved as a result of season extension is due to changes in the operations of regional carriers and the addition of new operations by the U.S. Coast Guard and port operators in support of winter navigation.

Following is a discussion of the approach taken to estimate changes in energy consumption for each of the three impact elements.

Elements of Energy Impact

Line Haul

Line haul movements are specified as origin to destination annual tonnages shipped either via a Great Lakes routing or an alternate routing. Two sets of such movements were used which represent two scenarios for shipping on the Great Lakes. The total annual tonnage moving between origin and destination does not change between scenarios but the split of tonnage between Great Lakes and alternate routes does differ in the two scenarios. This difference, resulting from extending the shipping season on the Great Lakes, can give rise to significant increases or decreases in the overall consumption of energy for moving freight between the affected origins and destinations. Energy savings from line haul movements are shown in Table 36.

Season extension will impact on two elements of energy consumption in addition to changes in line haul patterns. These are stockpiling and winter navigation support activities which are discussed separately below.

TABLE 36

LINE HAUL ENERGY CONSUMPTION
(Billion of Btu's per year)

Year	Commodity	Normal Season G.L.	Normal Season Other	Extended Season G.L.	Extended Season Other	Savings (Deficit)
1990	Grain	11,377	343,206	11,585	342,860	138
	Coal	9,966	20,857	10,029	20,733	61
	Iron Ore	32,110	17,749	32,245	17,268	346
	Gen. Cargo	5,300	119,039	6,077	118,094	168
	TOTAL	58,753	500,851	59,936	498,955	713
2000	Grain	13,011	527,516	13,957	526,090	480
	Coal	11,299	26,292	12,112	25,528	(49)
	Iron Ore	33,517	21,626	37,324	17,596	250
	Gen. Cargo	6,589	173,388	9,230	170,518	229
	TOTAL	64,416	748,822	72,623	739,705	910
2010	Grain	14,713	743,456	17,489	740,067	613
	Coal	11,624	34,318	14,572	31,643	(273)
	Iron Ore	33,332	30,791	42,719	21,175	229
	Gen. Cargo	8,008	254,374	13,100	248,637	645
	TOTAL	67,677	1,062,939	87,880	1,041,522	1,214
2020	Grain	15,371	954,915	18,161	951,483	642
	Coal	11,557	39,953	14,375	37,324	(189)
	Iron Ore	33,846	39,718	42,889	30,259	416
	Gen. Cargo	9,576	347,677	15,561	368,026	666
	TOTAL	70,350	1,409,263	90,986	1,387,092	1,535
2030	Grain	14,805	1,121,044	17,423	1,177,601	825
	Coal	11,594	46,584	14,321	43,973	(116)
	Iron Ore	34,858	50,977	43,630	41,609	596
	Gen. Cargo	11,538	553,813	18,560	546,130	661
	TOTAL	72,795	1,772,418	93,934	1,749,313	1,966

Stockpiling Energy

In some cases, extraordinary handling is required to manage the extra volumes of coal and iron ore inventories accumulated to maintain continuity of operations when the Great Lakes are closed to shipping. A reduction in this extraordinary handling is expected to result from season extension.

The incremental energy consumption attributable to seasonal fluctuations in inventories depends on the characteristics of the storage sites and handling equipment employed. These vary considerably from location to location. Significant energy savings occur where stockpile sites are located away from normal inventories.

Ice-breaker assistance

Provided by the United States Coast Guard, Ninth District Headquarters, Cleveland, Ohio. Vessel requirements in ice-breaker operations are for three distinct types: Class B Ice-Breakers which are capable of breaking two to three feet of ice without backing and ramming; and Class C Ice-Breakers which are specially equipped smaller vessels capable of breaking 1-1/2 to two feet of ice without backing and ramming; additionally, the Coast Guard now uses and will continue to use its five 180-feet buoy tenders during the winter navigation season.

Air reconnaissance operations

Provided by the Coast Guard. Regularly scheduled flights of specially-equipped aircraft will document ice and weather conditions. For this type of coverage, Side Looking Airborne Radar (SLAR) is currently being used.

Localized Improvements

Will be provided by various sources including the Coast Guard and Army Corps of Engineers, as well as numerous non-Federal sources. Five forms of localized improvements with significant energy effects have been identified:

Bubbler systems, which deter ice formation in restricted areas by the use of compressed air to circulate water, are planned for many harbors and confined channel areas with tight turns.

Local tugboat ice-breaking capabilities will also be needed at many of the Great Lakes ports. These tugs must not only assist the movement of vessels in and out of the harbors, but have the capability of keeping the immediate harbor area navigable. None of these will be Federally owned or operated.

Lock improvements will be needed at several locations to assist in keeping the locks free from ice.

Semi-permanent ice-control structures and permanent aids-to-navigation will be necessary at almost all the harbors. Semi-permanent structures include ice-booms which must be deployed at the start of the winter season and removed in the Spring. In addition, the present network of seasonal navigation aids (removed during the Winter season) must be replaced by all-season aids.

Other associated local improvements, which may be necessary such as channel dredging, ferry operations or pilot access operations.

Season Extension Energy Impacts Summary

Energy to support winter navigation infrastructure is summarized in Table 37.

The net impacts of season extension are summarized in Table 38.

TABLE 37

SUMMARY OF ESTIMATED ENERGY CONSUMPTION BY SUPPORT SYSTEMS FOR AN EXTENDED NAVIGATION SEASON INFRASTRUCTURE

(In Billions Btu's)

Year	CG Ice-Breaker	CG Air Reconnaissance	Bubblers	Local Tugs	Ice Breaking Tugs at Locks	Semi-Permanent Ice Controls	Other Associated	Total
1990	373	21	59	8	99	38	52	650
2000	459	21	59	34	99	38	52	762
2010	459	21	59	80	99	38	52	808
2020	459	21	59	78	99	38	52	806
2030	459	21	59	79	99	38	52	807

TABLE 38

SEASON EXTENSION ENERGY IMPACTS

(Billions of Btu's per Year)

Energy Impact Area*	1990	2000	2010	2020	2030
Net Line Haul Savings	713	910	1,214	1,535	1,966
Less Infrastructure					
Energy Use:					
Ice Breakers	373	459	459	459	459
Air Reconnaissance	21	21	21	21	21
Bubblers	59	59	59	59	59
Local Tugs	8	34	80	78	79
Tugs at Locks	99	99	99	99	99
Semi-Permanent Ice Controls	38	38	38	38	38
Other Associated Impacts	52	52	52	52	52
Total Infrastructure Costs	650	762	808	806	807
Net Energy Savings	63	148	406	729	1,159

*Stockpiling energy saving while considered sizeable is not listed because of difficulty of obtaining suitable data.

ECONOMIC REVIEW OF WINTER NAVIGATION BY THE STATE OF MICHIGAN AND THE STATE OF NEW YORK

Before the final part of the economic analysis of this Appendix is presented, consideration must be given to three reports that reviewed the economic analysis of the March 1979 Draft Survey Study for Great Lakes and St. Lawrence Seaway Navigation Season Extension. The first study "Economic Review of Winter Navigation," June 1, 1979, was prepared by the Great Lakes Basin Commission at the request of Michigan's Governor William G. Milliken. The second study "A Critique of the Recommended Plan of the U.S. Army Corps of Engineers," July 1979, was undertaken by the Pennsylvania State University Transportation Institute under contract to the New York State Department of Transportation. The third report was prepared by the Association of American Railroads in September 1979 and presented a "Summary of Principal Findings."

Great Lakes Basin Commission Report

The Great Lakes Basin Commission study raised five major questions related to the economic analysis:

1. transportation rate savings are both overstated in some cases and understated in others;

2. stockpiling benefits should be entirely eliminated;

3. winter rate savings are overstated;

4. alternatives to expand lock capacity were not considered; and

5. regional benefits are overstated and should be discounted.

The major questions raised by the GLBC have been considered in the economic analysis of the report; those questions that pointed out weaknesses in the March 1979 report, and found to be valid were adopted for this analysis. The following is a summary response to the questions raised by the GLBC:

1. Transportation rate savings:

a. Overstated

The GLBC perceived some problems with economic issues arising from use of the 1966 Transportation Act provisions for using prevailing rates as a measure of savings between transport modes. The use of rates is a Congressional mandate contained in the Transportation Act (1966). For this reason, the issue of rates vs. costs was not considered in this analysis. Furthermore, data are not available on costs of overland transportation to accurately construct a comparison of rate and cost structure.

b. Understated

The stockpile related benefits in the March 1979 report were developed prior to completion of the final report on System Lock Capacity in April 1979. The Lock Capacity Study concludes that without season extension, capacity will be reached at the Soo Locks in 1990. Thus, benefits based on the logistics of stockpiling would no longer be valid. With capacity conditions prevailing in summer months, it would no longer be feasible to stockpile during the winter for summer shipment. Consequently, the comparative season extension with and without conditions would revert to rail vs. water instead of stockpile vs. water shipment.

As a result of this logic, the GLBC recommended a higher correlation between winter navigation and lock capacity analyses. The GLBC's comment is valid and a higher correlation has been used for this study. Lock related stockpile benefits have been limited to the capacity of the locks. Lock capacity for the Soo Locks, with season extension, is projected to occur in year 2010. Therefore, lock related stockpile benefits as shown in Table 14 are limited after year 2010. Although the

stockpile benefits are not truncated beyond year 2010, they are limited between 27,694,000 tons in year 2010 to 27,999,000 tons in year 2040.

Table 14 also displays non-lock tons saved from the stockpile. This stockpile tonnage is that tonnage saved from the stockpile that does not have to go through the locks; for example, iron ore shipments out of Escanaba Harbor would not have to go through the Soo Locks.

2. Stockpiling Benefits Should be Eliminated Entirely:

Stockpiling benefits take into account savings in inventory resulting from winter movement of iron ore and coal. The commodities are stockpiled rather than moved by alternative modes during the winter because of the higher costs of land transportation. The use of stockpiling as a base case is proper because it is the current most economic business practice. Stockpiling redistribution of tonnage is valid as long as lock capacity exists to move that tonnage during the normal season. Once lock capacity is reached, transportation rate savings are applicable to the tonnage beyond and above the base capacity of the system. Stockpiling savings apply to the base below the capacity point. No stockpile or rate savings would accrue after year 2010 which is when lock capacity is reached at the Soo with season extension.

As stated above, stockpile benefits remain valid even with lock capacity constraints. With or without lock capacity being reached in 1990, the end result is that the presently stockpiled tonnage will be eliminated as a result of either: (1) lock capacity forcing the tonnage by overland mode, or (2) winter navigation facilitating a continuous waterborne shipment. Under the latter condition, as analyzed in this report, stockpile related benefits would accrue up to the next capacity period of 2010, the level at which capacity would be reached with season extension given present lock configuration.

3. Winter Rate Savings Overstated:

These savings represent the offsetting of higher winter variable costs, such as fuel and labor, by increased vessel trips and productivity. Only the largest, most powerful ships show a strong incremental improvement in cost performance beyond 10-months. The smaller ships do not achieve a measurable improvement beyond 10-months.

The Corps does not agree with the GLBC's conclusions in this case. Savings were taken only for the relatively new vessels which would make up the majority of the winter fleet. Furthermore, the 1975 existing fleet was used to measure such savings; a projected future fleet, which was not used, would result in a greater return for capitalization over the extended season.

4. Alternative to Expand Capacity Were Not Considered:

The Draft Maximum Ship Size Study concluded that for the upper lakes the highest net benefits occur if upper lakes locks constraints were removed before season extension. Our current work indicates the reverse has larger potential. Sabin Lock replacement is being considered in greater detail as part of the plan formulation process for Connecting Channels and Harbors.

Although there is some merit to combining all potential GL/SLS improvements into a system study, there is presently no authority to analyze season extension, lock replacement, and connecting channels on a common time frame. Therefore, these alternatives are not considered for this report.

5. Regional Benefits Are Not Discounted Back to Present Value:

An Intermodal impact analysis of revenue and tonnage impacts on rail and other non-Great Lakes Modes from season extension is included in this Appendix. Regional multipliers are being used over a 50-year period to be consistent with other project benefits and costs. The regional transfer payments do not have physical implementation costs associated with the benefits. Therefore, the discounting for comparison purposes with associated costs is not appropriate for this analysis. The real costs are accounted for under the National Economic Development Account.

Concerns raised by the GLBC's analysis were evaluated and incorporated in the appropriate economic analysis portion of this report.

New York State Report

The New York State report, prepared by the Pennsylvania Transportation Institute of Pennsylvania State University, has as a primary concern the impact of an extended season program on the State of New York. In this context, questions are raised concerning the calculation of transportation, winter rate, and stockpiling savings displayed in the report.

Several questions of the Pennsylvania Transportation Institute reflect items of law or policy. The use of transportation rates is mandated by Section 7a of Public Law 89-670, and the Water Resources Council provides the interest rate applicable to water resource projects. Some questions, such as whether or not lock capacity estimates are accurate, are rhetorical with no analytical backup.

Six major questions raised did contain analytical background. These questions and the work underway to resolve them are discussed below:

(1) Concerning the testing of the Great Lakes-St. Lawrence Seaway Traffic Model, additional model calibration work is now underway to incorporate the Origin and Destination Study for Foreign Trade for 1976 as carried out by the Bureau of Census for the Department of Transportation, the Corps of Engineers, and the Maritime Administration.

(2) Concerning the weight or value given to each service factor and rate, each switch in the model has been rank ordered with the same maximum potential power. The actual values and settings for the service switches reflect the outcome of the shipper preference survey.

(3) Concerning the evaluation of risk in shipping during the winter, this is a sensitivity question addressed in the season extension service switch. The response to the season extension service factor varied considerably depending upon the commodity group value and handling characteristics. An insurance study by the Maritime Administration, completed in 1972 and updated in 1979, addressed this issue of risk as well.

(4) Concerning projections showing diversions of traffic, the power of the season extension switch to divert cargo was the result of 120 shipper sensitivity interviews as reflected in the shipper reaction profile. These results are the basis of general cargo projections contained in the Survey Report, projections of which the Pennsylvania Transportation Institute is highly critical.

(5) Concerning the problem of increased shipment time as lock capacity nears, this tendency could be considered as an additional benefit factor for season extension as traffic is redistributed from normal season to extended season. The net effect or benefit has not been measured because preliminary studies indicate that a delay of a few days does not result in inventory costs large enough to offset line haul traffic savings.

(6) Concerning the need for statistical tests and validation of rate equations, additional statistical calculation has been incorporated for rate range dispersions.

Refinements made in the calculation of transportation, winter rate, and stockpile savings since the March 1979 Draft Report at least partially address other questions posed in the New York State report. Other concerns will be included in the scope of work to update the Traffic Model. Value judgments, legislative issues, and other qualitative comments are being addressed in ongoing sensitivity analysis.

Association of American Railroads Report

The Association of American Railroads (AAR) review of the March 1979 survey report raised numerous questions. The sum of the questions related to the type of rates used in the economic analysis, and the procedures used in calculating the various transportation savings for the study. The major questions raised by the AAR have been considered in the economic analysis of this report. The economic questions raised by the AAR in their review of the March 1979 report, and found to be valid, were adopted for this analysis. For example, the AAR raised the question that coal shipments from Lake Erie ports to Lake Michigan ports are not constrained by lockage capacity; consequently, transportation rate savings on coal traffic not constrained by lock capacity should be computed differently. Based on this comment and comments from others, lock capacity constraints on tonnages and savings have been corrected in this report. For instance, coal shipments and other shipments that do not have to go through the locks have been evaluated separately as non-lock benefits. All transportation savings and stockpile savings allow for lock capacity problems, and use the least cost alternative as a basis of comparison.

Many of the AAR's review questions pertained to the type rates and procedures used in the economic analysis. The economic analysis for this study, as with all Corps of Engineers water resources projects, is based on

existing laws and procedures in regard to calculating benefits. For example, the use of transportation rates is mandated by the 1966 Transportation Act (PL 89-670). The standards and criteria for economic evaluation of water resources projects are developed by the Water Resources Council which was established by Public Law 89-90. In this regard, the economics of this report will not reflect all the concerns raised by the AAR.

The following is a summary of major questions raised by the AAR and responses to those questions:

Concerning the computation of winter rate and stockpiling savings, the Association of American Railroads states that the correct way to compute winter rate savings is to limit the winter rate savings to only that coal and iron ore that moves during the normal season but without an extended season there would be no increase in capacity, which would allow for a reduction in the annual Great Lakes freight rate, based on the fact that vessel operators can spread their capital cost over a longer period of time, resulting in increased revenue. The reduction in the freight rate brought about by winter navigation is an annual rate; therefore, it is correct to apply it to induced and normal season base tonnages. Note the December 1979 report has improved upon the March 1979 report in that the operational plan winter rate savings have been netted out of all proposals in the December report.

The Association has specific questions concerning the calculation of transportation rate savings for iron ore. It would like some consideration of alternative sources of iron ore, and dislikes the use of "paper rates" in some instances to calculate transportation rate savings. Calculation of transportation savings in the Survey Report is based on actual existing iron ore movements. On the basis of the cost of a delivered iron unit, the cost of shipping iron ore from areas not on the GL-SLS Navigation System would far outweigh the cost of shipping the iron ore produced within the region.

The Association believes that transportation rate savings on coal traffic not requiring use of the Soo or Welland Canal locks could be overstated. Shipments that do not have to go through the locks have been evaluated separately as non-lock benefits and are compared to the least cost alternative way of moving the commerce.

Concerning a comparison of rates for overseas grain shipments, prevailing rates of 1977 were the basis of determining the relative value of transportation via Great Lakes and least cost alternative. Origin-destination routes were chosen that best represent the movement of grain to the St. Lawrence Seaway and overseas. The source for grain ocean rates was Chartering Annual of Maritime Research, Inc.

The Association questions the procedure used to evaluate transportation rate savings on general cargo traffic since it is based on constructed truck, rail, and vessel rates, rather than actual rates. Rate calculator equations were developed on the basis of key transportation variables such as distance, weight, cubic space, value and rate territory. In many cases rates quotes are not available at a reasonable cost and rate calculator equations are viewed as a reasonable cost effective way of measuring relative rates between alternatives for a Survey Study.

The Association believes that the regression analysis used to construct vessel rates was based on a very limited number of rate observations for some foreign trade routes. For other foreign routes, no rate observations were availabe from and to the Great Lakes. The high tonnage routes to Northern Europe and Japan which together account for 80 to 90% of the Great Lakes actual trade movements are based on a statistically valid number of rate observations. Additional investment of study resources in small tonnage routes would not materially change the overall magnitude of transportation rate savings.

The Association notes that constructed rail rates on container traffic were based on single carload rates. This overstates rail rates to

competitive Atlantic ports since lower multiple-container rates are in effect. In response, the government consultant was instructed to use the most common method of shipment in establishing the rate basis. The expert judgement of the consultant was G.L. potential container traffic was not usually shipped on a multi-container basis.

The Association believes that the Shipper Preference Study does not adequately explain how the proposed project will overcome the terminal and service deficiencies of the GL-SLS route. It is anticipated that a guarantee of extended season operations along the Seaway would serve as an incentive for shipping firms and port authorities to improve their general cargo business and facilities at ports throughout the Great Lakes such as now being developed at mouth of the Calumet River in Chicago. It should be noted that Season Extension will not increase the market share of Great Lakes navigation but prevent diversion of current share to other modes. The induced traffic for benefit purposes is a declining market share basis.

The Association indicates that the evaluation of transportation rate savings on general cargo made by the draft study significantly overstates traffic and savings. General cargo traffic growth has been tied to the long term growth in G.N.P. General cargo is better able to bear additonal winter related variable costs because the magnitude of the transportation differential is higher than for other commodities.

The Association notes that the extension of the Seaway navigation season to 11 months is estimated by the draft study to generate incremental transportation rate savings ranging from \$20.00 to \$33.00 per ton. There is no data in the report to support the magnitude of these per ton incremental transportation rate savings. Since the March report, the recommended plan has been changed from 11 months to 10 months. Also, the projected cargo mix for this report includes a larger proportion of grain. Therefore, the magnitude of incremental transportation rate savings on a total basis has been reduced. Also, the total average savings for all

commodities remains in the $5.00 to $8.00 range for each proposal. Incremental per ton savings for each proposal for this report ranges from $9.60 to $18.00.

A final concern, that of conducting sensitivity studies in accordance with recently published procedures of the Water Resources Council, is now being met through ongoing sensitivity analysis.

BENEFITS AND COSTS

This part of Appendix D discusses the benefits and costs associated with the proposals to extend the navigation season on the Great Lakes-St. Lawrence Seaway System, including the recommended plan of season extension in more detail.

The economic feasibility of the proposals to extend the navigation season is determined by comparing equivalent average annual charges; i.e., interest, amortization, operation and maintenance, and any cost disbenefits, with an estimate of the average annual transportation-related benefits that will accrue over the selected 1990-2040 period of analysis. The value given to benefits and costs at the time of their accrual is made comparable by conversion to an equivalent time basis using an interest rate of 7-1/8 percent, the current rate applicable to public water resources projects.

COST OF NAVIGATION SEASON EXTENSION

The entire Great Lakes-St. Lawrence Seaway System was analyzed as the requirements considered necessary to extend the navigation season in the following areas: (1) each of the five Great Lakes, (2) Great Lakes connecting channels including the Welland Canal, (3) Locks in the St. Marys River, Welland Canal and St. Lawrence River, (4) harbors in the entire system, and (5) the St. Lawrence River. Table 39 summarizes those requirements and costs associated with the proposals to extend the navigation season throughout the system, including the recommended plan. The requirements and costs of the recommended plan are depicted in detail in Appendix B. Costs are

based on October 1979 prices and include engineering, design, supervision and administration of construction.

The first costs for all the improvements shown in Table 39 include both initial capital costs and replacement costs. Replacement costs for each particular improvement are discounted back to present worth at 7-1/8 percent based on the useful life of the improvement. For example, if a certain improvement has a useful life of 10 years, then it is assumed that replacement costs would accrue in the 10th, 20th, 30th and 40th year of the 50-year project life. This stream of replacement costs is then discounted back to present worth and combined with initial capital costs and interest during construction to derive the total investment costs of the improvement. Interest during construction is accrued to items of two or more years construction time.

The first costs, total investment costs, and annual costs for the recommended plan have been time phased in accordance with the Phased Implementation sequence discussed in Appendix B. The base date for all costs is 1987, the same as that of the benefits.

TABLE 39

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
ICEBREAKING	USCG						
Total Investment		86,003	90,537	158,416	162,355	165,543	165,543
Annual Interest & Amortization		6,330	6,664	11,661	11,950	12,185	12,185
Annual Operation & Maintenance		4,580	5,070	8,180	8,670	9,160	9,160
Total Annual Cost		10,910	11,734	19,841	20,620	21,345	21,345
ICEBREAKER MOORING IMPROVEMENTS	USCG						
Total Investment		7,099	7,838	12,236	13,396	13,915	13,915
Annual Interest & Amortization		523	577	901	986	1,024	1,024
Annual Operation & Maintenance		-	-	-	-	-	-
Total Annual Cost		523	577	901	986	1,024	1,024
VESSEL TRAFFIC CONTROL	USCG						
Total Investment		357	357	841	841	841	841
Annual Interest & Amortization		26	26	62	62	62	62
Annual Operation & Maintenance		118	118	452	452	452	452
Total Annual Cost		144	144	514	514	514	514
ICE/DATA COLLECTION/ DISSEMINATION SYSTEM	USCG						
Total Investment		353	353	363	363	363	363
Annual Interest & Amortization		26	26	27	27	27	27
Annual Operation & Maintenance		248	248	260	260	260	260
Total Annual Cost		274	274	287	287	287	287

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)[1/]

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
AIDS TO NAVIGATION	USCG/SLSDC						
Total Investment		3,834	6,157	9,307	9,307	9,307	9,307
Annual Interest & Amortization		282	453	685	685	685	685
Annual Operation & Maintenance		3	121	123	123	123	123
Total Annual Cost		285	574	808	808	808	808
ICE CONTROL STRUCTURES	CORPS/SLSDC						
Total Investment		619	999	2,737	3,363	7,181	7,181
Annual Interest & Amortization		46	74	201	248	529	529
Annual Operation & Maintenance		87	109	193	213	389	389
Total Annual Cost		133	183	394	461	918	918
AIR BUBBLER SYSTEMS	CORPS						
Total Investment		1,824	1,824	1,824	1,824	1,824	1,824
Annual Interest & Amortization		134	134	134	134	134	134
Annual Operation & Maintenance		122	122	122	122	122	122
Total Annual Cost		256	256	256	256	256	256
LOCK MODIFICATIONS	CORPS/SLSDC						
Total Investment		9,339	12,955	12,955	12,955	22,774	23,300
Annual Interest & Amortization		687	954	954	954	1,676	1,715
Annual Operation & Maintenance		500	793	793	916	1,241	1,608
Total Annual Cost		1,187	1,747	1,747	1,870	2,917	3,323

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	1	2	3	4	PROPOSAL 5	6
DREDGING	CORPS/SLSDC						
Total Investment		55,791	55,791	55,791	55,791	55,791	99,584
Annual Interest & Amortization		4,107	4,107	4,107	4,107	4,107	7,330
Annual Operation & Maintenance		174	174	174	174	174	221
Total Annual Cost		4,281	4,281	4,281	4,281	4,281	7,551
COMPENSATING WORKS	CORPS						
Total Investment		-	-	17,209	17,209	17,209	17,209
Annual Interest & Amortization		-	-	1,267	1,267	1,267	1,267
Annual Operation & Maintenance		-	-	204	204	204	204
Total Annual Cost		-	-	1,471	1,471	1,471	1,471
SHORELINE & SHORE STRUCTURE PROTECTION	CORPS/SLSDC						
Total Investment		2,092	2,992	3,915	4 349	4,981	5,659
Annual Interest & Amortization		154	220	288	320	367	417
Annual Operation & Maintenance		37	46	57	64	73	89
Total Annual Cost		191	266	345	384	440	506
ISLAND TRANSPORTATION ASSISTANCE	CORPS/SLSDC						
Total Investment		-	-	-	-	883	883
Annual Interest & Amortization		-	-	-	-	65	65
Annual Operation & Maintenance		12	40	40	66	43	64
Total Annual Cost		12	40	40	66	108	129

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)[1/]

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
WATER LEVEL MONITORING	CORPS						
Total Investment		158	158	194	194	194	194
Annual Interest & Amortization		12	12	14	14	14	14
Annual Operation & Maintenance		29	29	81	81	81	81
Total Annual Cost		41	41	41	41	41	41
ENVIRONMENTAL PLAN OF ACTION	INTERIOR/						
Total Investment	CORPS	51,527	70,040	113,550	113,550	113,550	114,694
Annual Interest & Amortization		3,793	5,155	8,358	8,358	8,358	8,442
Annual Operation & Maintenance		-	-	-	-	-	-
Total Annual Cost		3,793	5,155	8,358	8,358	8,358	8,442
PILOT ACCESS	NON-FED						
Total Investment		578	1,256	1,795	1,795	2,821	2,821
Annual Interest & Amortization		43	92	132	132	208	208
Annual Operation & Maintenance		11	23	34	63	113	187
Total Annual Cost		54	115	166	195	321	395
CHANNEL CLEARING CRAFT	SLSDC						
Total Investment		-	-	-	-	-	3,651
Annual Interest & Amortization		-	-	-	-	-	269
Annual Operation & Maintenance		-	-	-	-	-	396
Total Annual Cost		-	-	-	-	-	665

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
ICE AND WEATHER FORECAST	NOAA						
Total Investment		48	48	48	48	48	48
Annual Interest & Amortization		4	4	4	4	4	4
Annual Operation & Maintenance		244	244	244	244	244	244
Total Annual Cost		248	248	248	248	248	248
CHANNELS & LAKES SUBTOTALS	-						
Total Investment		219,622	251,111	390,987	397,146	417,031	466,823
Annual Interest & Amortization		16,166	18,483	28,779	29,232	30,696	34,361
Annual Operation & Maintenance		6,165	7,137	10,957	11,651	12,678	13,599
Total Annual Cost		22,331	25,620	39,736	40,883	43,374	47,960
ASHLAND, WIS.	NON-FED						
Total Investment		194	194	194	194	194	194
Annual Interest & Amortization		14	14	14	14	14	14
Annual Operation & Maintenance		581	581	581	581	581	581
Total Annual Cost		595	595	595	595	595	595
MARQUETTE, MICH.	NON-FED						
Total Investment		194	194	194	194	194	194
Annual Interest & Amortization		14	14	14	14	14	14
Annual Operation & Maintenance		129	129	129	129	129	129
Total Annual Cost		143	143	143	143	143	143

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
ESCANABA, MICH.	NON-FED						
Total Investment		2,398	2,398	2,398	2,398	2,398	2,398
Annual Interest & Amortization		176	176	176	176	176	176
Annual Operation & Maintenance		532	532	532	532	532	532
Total Annual Cost		708	708	708	708	708	708
GREEN BAY, WIS.	NON-FED/						
Total Investment	USCG	2,071	2,071	2,071	2,071	2,071	2,071
Annual Interest & Amortization		152	152	152	152	152	152
Annual Operation & Maintenance		76	76	76	76	76	76
Total Annual Cost		228	228	228	228	228	228
CALUMET, ILL.	NON-FED						
Total Investment		1,238	1,238	1,238	1,238	1,238	1,238
Annual Interest & Amortization		91	91	91	91	91	91
Annual Operation & Maintenance		288	288	288	288	288	288
Total Annual Cost		379	379	379	379	379	379
INDIANA HARBOR, IND.	CORPS						
Total Investment		1,079	1,079	1,079	1,079	1,079	1,079
Annual Interest & Amortization		79	79	79	79	79	79
Annual Operation & Maintenance		74	74	74	74	74	74
Total Annual Cost		153	153	153	153	153	153

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
MUSKEGON, MICH.	CORPS/NON-FED						
Total Investment		2,059	2,059	2,059	2,059	2,059	2,059
Annual Interest & Amortization		152	152	152	152	152	152
Annual Operation & Maintenance		235	235	235	235	235	235
Total Annual Cost		387	387	387	387	387	387
LUDINGTON, MICH.	CORPS/NON-FED						
Total Investment		2,161	2,161	2,161	2,161	2,161	2,161
Annual Interest & Amortization		159	159	159	159	159	159
Annual Operation & Maintenance		242	242	242	242	242	242
Total Annual Cost		401	401	401	401	401	401
ALPENA, MICH.	NON-FED/USCG						
Total Investment		905	905	905	905	905	905
Annual Interest & Amortization		67	67	67	67	67	67
Annual Operation & Maintenance		213	213	213	213	213	213
Total Annual Cost		280	280	280	280	280	280
SILVER BAY, MINN.	NON-FED						
Total Investment		-	-	-	-	-	-
Annual Interest & Amortization		-	-	-	-	-	-
Annual Operation & Maintenance		25	25	25	25	25	25
Total Annual Cost		25	25	25	25	25	25

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
SAGINAW, MICH.	CORPS/NON-FED						
Total Investment	USCG	3,512	3,512	3,512	3,512	3,512	3,512
Annual Interest & Amortization		259	259	259	259	259	259
Annual Operation & Maintenance		280	280	280	280	280	280
Total Annual Cost		539	539	539	539	539	539
DULUTH, MINN-SUPERIOR, WIS.	NON-FED/USCG						
Total Investment		4,260	4,260	4,260	4,260	4,260	4,260
Annual Interest & Amortization		314	314	314	314	314	314
Annual Operation & Maintenance		1,477	1,477	1,477	1,477	1,477	1,477
Total Annual Cost		1,791	1,791	1,791	1,791	1,791	1,791
MONROE, MICH.	NON-FED						
Total Investment		-	-	553	553	553	553
Annual Interest & Amortization		-	-	41	41	41	41
Annual Operation & Maintenance		-	-	233	233	233	233
Total Annual Cost		-	-	274	274	274	274
TOLEDO, OHIO	USCG/NON-FED						
Total Investment		-	-	790	790	790	790
Annual Interest & Amortization		-	-	58	58	58	58
Annual Operation & Maintenance		-	-	76	76	76	76
Total Annual Cost		-	-	134	134	134	134

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	PROPOSAL 1	2	3	4	5	6
SANDUSKY, OHIO	NON-FED						
Total Investment		-	-	181	181	181	181
Annual Interest & Amortization		-	-	13	13	13	13
Annual Operation & Maintenance		-	-	580	580	580	580
Total Annual Cost		-	-	593	593	593	593
HURON, OHIO	CORPS/NON-FED						
Total Investment		-	-	1,098	1,098	1,098	1,098
Annual Interest & Amortization		-	-	81	81	81	81
Annual Operation & Maintenance		-	-	242	242	242	242
Total Annual Cost		-	-	323	323	323	323
LORAIN, OHIO	CORPS						
Total Investment		-	-	2,890	2,890	2,890	2,890
Annual Interest & Amortization		-	-	213	213	213	213
Annual Operation & Maintenance		-	-	126	126	126	126
Total Annual Cost		-	-	339	339	339	339
CLEVELAND, OHIO	CORPS						
Total Investment		-	-	2,100	2,100	2,100	2,100
Annual Interest & Amortization		-	-	155	155	155	155
Annual Operation & Maintenance		-	-	89	89	89	89
Total Annual Cost		-	-	244	244	244	244

TABLE 39 (Cont.)

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	Agency/ Activity	1	2	PROPOSAL 3	4	5	6
ASHTUBULA, OHIO	CORPS						
Total Investment		-	-	3,050	3,050	3,050	3,050
Annual Interest & Amortization		-	-	225	225	225	225
Annual Operation & Maintenance		-	-	135	135	135	135
Total Annual Cost		-	-	360	360	360	360
CONNEAUT, OHIO	CORPS						
Total Investment		-	-	3,205	3,205	3,205	3,205
Annual Interest & Amortization		-	-	236	236	236	236
Annual Operation & Maintenance		-	-	140	140	140	140
Total Annual Cost		-	-	376	376	376	376
BUFFALO, N.Y.	NON-FED						
Total Investment		-	-	-	-	-	-
Annual Interest & Amortization		-	-	-	-	-	-
Annual Operation & Maintenance		-	-	417	417	417	417
Total Annual Cost		-	-	417	417	417	417

TABLE 39

TOTAL PHASED U.S. ANNUAL COSTS OF NAVIGATION SEASON EXTENSION (IN $1,000)1/

Activity	PROPOSAL 1	2	3	4	5	6
HARBOR SUBTOTALS						
Total Investment	20,071	20,071	33,938	33,938	33,938	33,938
Annual Interest & Amortization	1,477	1,477	2,498	2,498	2,498	2,498
Annual Operation & Maintenance	4,152	4,152	6,189	6,189	6,189	6,189
Total Annual Cost	5,629	5,629	8,687	8,687	8,687	8,687
CHANNELS & LAKES SUBTOTALS						
Total Investment	219,622	251,111	390,987	397,146	417,031	466,823
Annual Interest & Amortization	16,166	18,483	28,779	29,232	30,696	34,361
Annual Operation & Maintenance	6,165	7,137	10,957	11,651	12,678	13,599
Total Annual Cost	22,331	25,620	39,736	40,883	43,374	47,960
GRAND TOTALS						
Total Investment	239,693	271,182	424,925	431,084	450,969	500,761
Annual Interest & Amortization	17,643	19,960	31,277	31,730	33,194	36,859
Annual Operation & Maintenance	10,317	11,289	17,146	17,840	18,867	19,788
Total Annual Cost	27,960	31,249	48,423	49,570	52,061	56,647

1/ Definition of Proposals:

Extended Season Proposals	Estimated Starting Date of Vessel Operations	Lake Superior St. Marys River Lake Michigan Straits of Mackinac Lake Huron	St. Clair River Lake St. Clair Detroit River Lake Erie	Welland Canal Lake Ontario St. Lawrence River
Base Condition	Prior to 1987	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1.	1987	Year-round	1 Apr - 31 Jan	1 Apr - 15 Dec
2.	1990	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3.	1990	Year-round	Year-round	1 Apr - 31 Dec
4.	1992	Year-round	Year-round	20 Mar - 31 Dec
5.	1995	Year-round	Year-round	7 Mar - 7 Jan
6.	2000	Year-round	Year-round	7 Feb - 7 Jan

ECONOMIC JUSTIFICATION - ALTERNATIVE PROPOSALS AND RECOMMENDED PLAN

Benefits of March 1976 Interim Feasibility Study

In order to accurately determine the economic feasibility of the alternative proposals to extend the navigation season, it is necessary to subtract out the benefits contained in the March 1976 Interim Feasibility Study to extend the navigation season to 31 January (± 2 weeks) on the upper four Great Lakes from the total benefits associated with each of the proposals (as shown in Table 14. This prevents duplicating benefits and assures that only those incremental benefits that are in excess of those contained in the March 1976 Interim Feasibility Study are allocated to each proposal. Table 40 displays both the latest annual benefits and costs associated with the March 1976 Study, derived using the GL/SLS Traffic Model, as well as the annual benefits and costs associated with the 1976 study as contained in the November 1977 Chief of Engineers report, which is currently with the Congress. These latter figures essentially represent only a price index update to November 1977 of the original benefits and costs contained in the March 1976 Report. In order to maintain consistency with the methodology used to derive the total benefits associated with each of the current proposals to extend the navigation season, the latest benefits associated with the March 1976 Interim Feasibility Study, derived using the GL/SLS Traffic Model, were subtracted out from the total benefits of each proposal.

Benefit/Cost Ratios of Alternative Proposals and Proposed Plan

Table 41 shows a summary of the estimated benefits, the estimated costs and the ratio of benefits to costs for the proposals to extend the navigation season, including the recommended plan of season extension. As shown in this table, each of these proposals is

economically justified. Although proposal 6 maximizes net benefits, it is not selected as the recommended plan because environmental impacts associated with the dredging needed for this proposal have not been fully quantified. However, for proposal 6, a minimum level of dredging to meet the needs of an 11-month extension on the seaway has been costed out, which leaves this proposal as a viable option in the future. With the maximum level of dredging for proposal 6, the total investment costs for proposal 6 would be $555,516,000, average annual costs would be $60,767,000 with a B/C ratio of 3.6, and net benefits of $159,381,000. Being that maximum level of dredging does not maximize net benefits greater than proposal 6 with minimum dredging, it is not considered further for analysis. However, the incremental B/C ratio obtained by adding on 11-months navigation on the St. Lawrence River, with a minimum level of dredging, to year-round extension on the upper four lakes is 8.3. This is derived by subtracting the benefits of extending the season 12-months on the upper four Great Lakes from those of proposal 6 ($220,148,000 - $124,096,000 = $96,052,000) and comparing the results to the difference in costs between the two proposals ($56,647,000 - $45,134,000 = $11,513,000).

TABLE 40

MARCH 1976 INTERIM FEASIBILITY STUDY
AVERAGE ANNUAL U. S. BENEFITS AND COSTS
(In $1,000)

AVERAGE ANNUAL BENEFITS	Latest Benefits and Costs 1/ 2/	Data in Report at Congress 3/
Transp. Rate Savings	$ 0	$ (0)
Winter Rate Savings	4,982	(6,411)
Stockpile Savings	5,471	(7,511)
TOTAL	$10,453	($13,922)
AVERAGE ANNUAL COSTS		
Total Investment Costs	$55,732	($42,636)
Annual Costs:		
Interest & Amortization	4,102	(2,944)
Operations & Maintenance	3,187	(2,197)
	$7,289	($ 5,141)
Benefit/Cost Ratio	1.4	(2.7)

1/ Annual U. S. Benefits derived using current data in the GL/SLS Traffic Model

2/ Transportation rate savings were not tabulated in the March 1976 Feasibility Study. These benefits which were not counted as part of the operational plan must be subtracted from subsequent plans for proper incremental analysis. As a result, 27.4 million dollars of transportation rate savings resulting from the operational plan recommended in the March 1976 Feasibility Study are not tabulated as part of the subsequent season extension proposals.

3/ November 1977 Chief of Engineers Report at 6-5/8%.

TABLE 41 1/

AVERAGE ANNUAL U.S. BENEFITS AND COSTS (IN $1,000 at 7-1/8%) DAYLIGHT OPERATION ON WELLAND-SEAWAY IN WINTER

Avg Annual Benefits	PROPOSAL 1	PROPOSAL 2	PROPOSAL 3	PROPOSAL 4	PROPOSAL 5	PROPOSAL 6 2/
Transp. Rate Savings	92,012	95,062	99,246	113,052	123,916	136,259
Winter Rate Savings	7,350	7,359	7,397	7,405	7,405	7,405
Stockpile Savings	11,996	13,075	21,493	22,695	23,239	23,239
TOTAL	111,358	115,496	128,136	143,152	154,560	166,903
Avg Annual Costs						
Total Investment Cost	239,693	271,182	424,925	431,084	450,969	500,761
Annual Costs:						
Interest & Amortization	17,643	19,960	31,277	31,730	33,194	36,859
Operations & Maintenance	10,317	11,289	17,146	17,840	18,867	19,788
TOTAL	27,960	31,249	48,423	49,570	52,061	56,647
Benefit/Cost Ratio	4.0	3.7	2.6	2.9	3.0	2.9
Net Benefits						
Benefit minus Costs	83,398	84,247	79,713	93,582	102,499	110,256

TABLE 41 1/ (Cont.)

AVERAGE ANNUAL U.S. BENEFITS AND COSTS (IN $1,000 at 7-1/8%) 24 HOUR OPERATION ON WELLAND-SEAWAY IN WINTER

Avg Annual Benefits	PROPOSAL 1	PROPOSAL 2	PROPOSAL 3	PROPOSAL 4	PROPOSAL 5	PROPOSAL 6 2/
Transp. Rate Savings	92,012	141,883	146,165	162,431	175,022	188,986
Winter Rate Savings	7,350	7,359	7,397	7,405	7,405	7,405
Stockpile Savings	11,996	13,075	21,493	22,695	23,239	23,757
TOTAL	111,358	162,317	175,055	192,531	205,666	220,148
Avg Annual Costs						
Total Investment Cost	239,693	271,182	424,925	431,084	450,969	500,761
Annual Costs:						
Interest & Amortization	17,643	19,960	31,277	31,730	33,194	36,859
Operations & Maintenance	10,317	11,289	17,146	17,840	18,867	19,788
TOTAL	27,960	31,249	48,423	49,570	52,061	56,647
Benefit/Cost Ratio	4.0	5.2	3.6	3.9	4.0	3.9
Net Benefits						
Benefits minus Costs	83,398	131,068	126,632	142,961	153,605	163,501

TABLE 41 1/ (Cont.)

1/ Definition of Proposals:

Extended Season Proposals	Estimated Starting Date of Vessel Operations	Lake Superior St. Marys River Lake Michigan Straits of Mackinac Lake Huron	St. Clair River Lake St. Clair Detroit River Lake Erie	Welland Canal Lake Ontario St. Lawrence River
Base Condition	Prior to 1987	1 Apr - 31 Jan	1 Apr - 31 Jan	1 Apr - 15 Dec
1	1987	Year-round	1 Apr - 31 Jan	1 Apr -15 Dec
2	1990	Year-round	1 Apr - 31 Jan	1 Apr - 31 Dec
3	1990	Year-round	Year-round	1 Apr - 31 Dec
4	1992	Year-round	Year-round	20 Mar - 31 Dec
5	1995	Year-round	Year-round	7 Mar - 7 Jan
6	2000	Year-round	Year-round	7 Feb - 7 Jan

NOTE: March 1976 Interim Feasibility Report recommends an extended season program on the upper four Great Lakes to 31 January (± 2 weeks). This is the Base Condition shown above.

1/ The word "proposal" identifies sub-divisions of an overall plan. These proposals have not been developed as exclusive alternatives.

2/ Based on minimum levels of dredging.

ECONOMIC JUSTIFICATION - HARBORS IN RECOMMENDED PLAN

Harbor Criteria

The criteria for harbors selected for evaluation are as follows:

a. waterborne commerce of the United States statistics were used to check each harbor's historical tonnages from 1972 to 1977;

b. harbors handling 250,000 tons or less were not evaluated unless it was determined that they would attract season extension sensitive commodities;

c. harbors receiving or shipping season extension sensitive commodities such as iron ore, coal, grains, and general cargo were evaluated.

Harbors such as Erie Harbor, Pennsylvania, Oswego Harbor, New York, and Rochester Harbor, New York, were evaluated in previous draft reports. However, based on more thorough evaluation of these harbors it was determined that they are not sensitive to navigation season extension.

Erie Harbor's traffic has consisted primarily of bulk commodities such as limestone, sand, and gravel, which are not shipped during the winter, and smaller amounts of iron and steel and fuel oil products. The harbor is not substantially engaged in handling iron ore, coal, and grain commodities which would be sensitive to extended season operations. General cargo tonnages are such that Erie Harbor would not be expected to handle significant amounts of these commodities during an extended season.

Oswego Harbor's receipts and shipments in 1977 totaled 1,346,112 tons. However, none of this tonnage, except for 19,747 tons of grain received at the harbor in 1977, is sensitive to navigation season extension. Rochester Harbor's receipts and shipments in 1977 totaled 206,457 tons. The major commodity received during this period was 190,524 tons of cement. Rochester Harbor was evaluated in previous

reports because it was projected that it would be a likely harbor to receive and ship general cargo. However, through a more thorough evaluation it was determined that high valued general cargo such as camera equipment, xerox machines, and other related photographic equipment manufactured in the Rochester Area would not be shipped by water.

Ogdensburg Harbor, New York, is a harbor that some commercial users in the area feel could benefit from navigation season extension. However, at the present time, it has not been found that Ogdensburg Harbor will attract navigation season extension sensitive traffic based on historical traffic trends for the harbor. Ogdensburg Harbor has been averaging approximately 250,000 tons per year.

Concern has been expressed that the implementation of a permanent navigation season extension could be a detriment to smaller harbors around the Great Lakes which would not engage in extended season operations. The types of commodities with which these harbors deal, however, such as pulp and paper, cement, and agricultural products, other than wheat, make it unlikely that the smaller harbors would lose traffic through diversion to winter navigation. Commodities sensitive to season extension, such as iron ore, coal, grain, and (manufactured) general cargo, do not in most cases comprise significant portions of the traffic entering and leaving the smaller harbors around the Great Lakes.

Port/Split

In the GL/SLS economic region, cargo flows to and from Bureau of Economic Analysis (BEA) areas located in the 19 states of this region. For origin or destination BEA's away from the lakes, no indication is given as to what lakeside BEA or port the cargo is shipped through. Traffic that has an origin or destination within a lakeside BEA can be assumed to usually move to an alternative coastal port or ports within the BEA. However, BEA's frequently contain more than one port.

To overcome the difficulty as to what ports commodities flow through, a port/split methodology was developed. The first step in developing port data was to develop specifications for a base case, or improved case. The total GL/SLS share versus the least cost/best alternative was then determined. This data base of total GL/SLS traffic included all the origins and destinations of the GL/SLS share split. This data base was screened and allocated to those ports which offer the best service at lowest overall transportation cost. An iterative screening process was employed to eliminate non-logical alternatives and lower the processing costs.

The first screen for traffic was applied to the hinterland origins and destinations. Each BEA was assigned to adjacent ports. For example, an Iowa BEA was assigned to Duluth, Milwaukee and Chicago. Lake Erie and Lake Ontario ports cannot compete on a cost or service basis for the Iowa BEA traffic, when the geographically adjacent ports offer service to the same water link.

The second screen allocated traffic to only those ports which have a capability of handling that major commodity group. Diversified general cargo in bags, barrels, and 20-foot containers should not be directed to ports solely equipped to handle a gravity-flow bulk commodity such as limestone.

The third screen applied directly to overseas and Canadian traffic and allocated commerce to only those ports with service to the appropriate foreign area. Traffic with an origin or destination in the Far East should only be allocated to those ports serving the Far East with ships on either a scheduled or inducement basis.

Traffic which was not allocated to one specific port because of the above screening process was directed to the port offering the least transportation cost to ultimate destination. At this point, the port traffic levels as developed were checked for approximate correspondence to historic traffic levels.

Projected Harbor Traffic

Table 42 depicts normal season and extended season traffic projections for those major Great Lakes harbors expected to benefit from the proposed plan to extend the navigation season, as determined by the port/split model. As discussed previously in this section, overall projected system traffic associated with the recommended plan, extended season traffic was defined as including only that traffic which moved through the Soo Locks, the Straits of Mackinac, the St. Clair-Detroit River system, the Welland Canal or the St. Lawrence River after 15 December. Therefore, traffic resulting from current normal winter operations (i.e., intra-lake traffic) was excluded from the analysis. Likewise, traffic not suited for winter navigation (such as limestone) was excluded from benefit calculations. The harbor traffic projections include only the movements which involve U.S. ports as either origin, destination, or both legs of the movement. Finally, the harbor traffic forecasts take into account the Lock Capacity Estimates discussed in previous sections of this appendix.

Harbor Benefits

The average annual stockpiling, transportation rate and winter rate savings that are expected to accrue to the major Great Lakes harbors having traffic benefiting from the recommended plan are summarized in Table 43. Average annual harbor benefits were derived using the same methodology discussed earlier to derive overall system benefits for the recommended plan. It should be noted that only those benefits are displayed in Table 43 which are in excess of those benefits associated with the Great Lakes operational plan, as contained in the March 1976 Interim Feasibility Report.

Harbor Costs

Table 44 depicts the derivation of the total annual costs of season extension for each of the major Great Lakes harbor expected to benefit from the recommended plan.

TABLE 42

NORMAL SEASON AND EXTENDED SEASON TRAFFIC PROJECTIONS
FOR HARBORS IN RECOMMENDED PLAN 1/
U. S. TRAFFIC, 1980-2040
(In 1,000 Tons)

Harbor	Length of Season	1980 2/	1987	1990 2/	1995 3/	2000 2/	2020	2040
Two Harbors	Normal Season	10,982	13,003	13,869	14,730	14,730	14,730	14,730
	Proposed Plan	11,095	13,136	14,064	15,557	16,961	19,484	19,484
Duluth-Superior	Normal Season	46,103	57,648	62,577	65,743	65,927	66,995	68,722
	Proposed Plan	47,179	59,088	65,029	71,377	76,934	87,693	89,600
Presque Isle	Normal Season	3,479	4,134	4,415	4,666	4,666	4,666	4,666
	Proposed Plan	3,519	4,181	4,478	4,915	5,325	6,064	6,064
Marquette	Normal Season	899	1,104	1,192	1,307	1,351	1,610	2,040
	Proposed Plan	921	1,130	1,226	1,432	1,625	2,099	2,547
Taconite	Normal Season	11,345	13,415	14,301	15,183	15,183	15,183	15,183
	Proposed Plan	11,461	13,552	14,502	16,039	17,485	20,057	20,057
Silver Bay	Normal Season	11,305	13,369	14,253	15,132	15,132	15,132	15,132
	Proposed Plan	11,421	13,506	14,453	15,986	17,427	19,994	19,994
Ashland	Normal Season	323	366	384	402	402	402	402
	Proposed Plan	326	370	389	429	466	510	510
Green Bay	Normal Season	1,347	1,671	1,810	2,105	2,399	3,841	5,705
	Proposed Plan	1,374	1,704	1,851	2,177	2,482	3,974	5,901

TABLE 42 (Cont.)

NORMAL SEASON AND EXTENDED SEASON TRAFFIC PROJECTIONS
FOR HARBORS IN RECOMMENDED PLAN 1/
U. S. TRAFFIC, 1980-2040
(In 1,000 Tons)

Harbor	Length of Season	1980 2/	1987	1990 2/	1995 3/	2000 2/	2020	2040
Milwaukee	Normal Season	4,834	5,132	5,252	5,450	5,597	6,439	7,799
	Proposed Plan	5,019	5,398	5,743	6,166	6,458	7,663	9,135
Calumet	Normal Season	13,880	15,048	15,548	16,322	16,721	19,004	21,967
	Proposed Plan	14,352	15,747	16,867	18,264	19,312	22,766	25,886
Indiana	Normal Season	12,469	13,916	14,536	15,345	15,544	16,638	17,916
	Proposed Plan	12,623	14,198	15,135	16,467	17,661	20,317	21,618
Burns	Normal Season	4,432	5,051	5,317	5,692	5,812	6,504	7,274
	Proposed Plan	4,481	5,111	5,443	5,990	6,529	7,933	8,719
Gary	Normal Season	8,013	8,991	9,410	9,969	10,122	10,976	11,959
	Proposed Plan	8,106	9,150	9,749	10,633	11,451	13,370	14,370
Escanaba	Normal Season	12,014	14,226	15,174	16,859	18,544	27,342	37,907
	Proposed Plan	12,150	14,387	15,437	17,234	18,959	27,958	38,761
Ludington	Normal Season	24	27	28	30	31	38	46
	Proposed Plan	26	30	36	41	45	63	76
Port Washington	Normal Season	2,921	3,185	3,298	3,486	3,622	4,401	5,693
	Proposed Plan	2,995	3,267	3,429	3,688	3,938	4,930	6,286

TABLE 42 (Cont.)

NORMAL SEASON AND EXTENDED SEASON TRAFFIC PROJECTIONS
FOR HARBORS IN RECOMMENDED PLAN 1/
U. S. TRAFFIC, 1980-2040
(In 1,000 Tons)

Harbor	Length of Season	1980 2/	1987	1990 2/	1995 3/	2000 2/	2020	2040
Saginaw	Normal Season	71	71	71	71	71	71	71
	Proposed Plan	80	81	85	86	86	86	86
St. Clair	Normal Season	2,247	2,696	2,889	2,970	2,970	2,970	2,970
	Proposed Plan	2,270	2,724	2,948	3,112	3,276	3,484	3,484
Detroit	Normal Season	14,638	16,417	17,176	18,023	18,326	19,859	22,131
	Proposed Plan	14,890	16,797	17,943	19,386	20,625	23,523	25,845
Alpena	Normal Season	76	92	98	113	126	190	285
	Proposed Plan	76	93	99	117	133	200	297
Toledo	Normal Season	16,990	18,992	19,848	21,159	22,014	26,021	30,840
	Proposed Plan	17,296	19,491	20,682	22,683	24,344	29,868	34,876
Sandusky	Normal Season	6,858	7,512	7,791	8,256	8,657	10,500	12,606
	Proposed Plan	6,968	7,700	8,110	8,764	9,306	11,399	13,600
Huron	Normal Season	2,627	3,074	3,265	3,498	3,554	3,816	4,091
	Proposed Plan	2,659	3,119	3,330	3,715	4,060	4,873	5,153

TABLE 42 (Cont.)

NORMAL SEASON AND EXTENDED SEASON TRAFFIC PROJECTIONS
FOR HARBORS IN RECOMMENDED PLAN 1/
U. S. TRAFFIC, 1980-2040
(In 1,000 Tons)

Harbor	Length of Season	1980 2/	1987	1990 2/	1995 3/	2000 2/	2020	2040
Lorain	Normal Season	5,391	6,255	6,626	7,069	7,165	7,622	8,114
	Proposed Plan	5,460	6,359	6,781	7,530	8,193	9,731	10,231
Cleveland	Normal Season	15,718	19,021	20,436	21,402	21,519	22,126	22,910
	Proposed Plan	15,983	19,466	21,206	23,109	24,616	28,699	29,504
Ashtabula	Normal Season	12,142	14,139	14,996	15,823	16,325	18,714	21,592
	Proposed Plan	12,321	14,431	15,461	16,742	17,816	21,498	24,501
Conneaut	Normal Season	15,956	18,685	19,854	21,110	21,661	24,277	27,424
	Proposed Plan	16,183	19,067	20,477	22,499	24,240	29,093	32,369
Buffalo	Normal Season	9,991	15,198	17,413	19,017	19,693	23,147	28,423
	Proposed Plan	10,392	15,730	18,191	21,120	23,684	30,013	35,710
Monroe	Normal Season	2,159	2,591	2,776	2,853	2,853	2,853	2,853
	Proposed Plan	2,181	2,617	2,833	2,990	3,147	3,348	3,348
Muskegon	Normal Season	366	443	476	543	610	907	1,307
	Proposed Plan	411	497	542	640	719	1,069	1,540

TABLE 42

NORMAL SEASON AND EXTENDED SEASON TRAFFIC PROJECTIONS
FOR HARBORS IN RECOMMENDED PLAN 1/
U. S. TRAFFIC, 1980-2040
(In 1,000 Tons)

1/ The traffic base only includes those four commodities that are expected to benefit from season extension: iron ore, coal, grain and general cargo. The traffic base was defined as including only that traffic which moved through the Soo Locks, the Straits of Mackinac, the St. Clair - Detroit River System or the St. Lawrence Seaway after 15 December. Traffic resulting from current normal winter operations (such as intra-lake movements of petroleum and other commodities) was excluded from the analysis. Likewise, traffic not suited for winter navigation (such as limestone) was excluded.

2/ For the normal season, it is estimated that capacity will be reached at the Welland Canal Locks in 1980, at the St. Lawrence Seaway Locks in 2000 and at the Soo Locks in 1990. With navigation season extension, it is estimated that tonnage capacity at those locks will be increased as shown in Table 8.

3/ Estimated start of year-round navigation on upper four Great Lakes and 10-month navigation on St. Lawrence River.

TABLE 43

TOTAL ANNUAL BENEFITS FOR HARBORS IN RECOMMENDED PLAN
(In $1,000 at 7-1/8%)

	Aver. Annual Transportation Rate Benefits	Aver. Annual Winter Rate Benefits	Average Annual Stockpile Benefits	Total Average Annual Benefits
Two Harbors, MN	$ 4,420	$ 71	$ 997	$ 5,488
Duluth-Superior, MN-WI	45,137	2,873	4,416	52,426
Presque Isle, MI	1,370	20	313	1,703
Marquette, MI	54	10	95	159
Taconite, MN	4,525	73	1,042	5,640
Silver Bay, MN	4,513	73	1,037	5,623
Ashland, WI	186	8	56	250
Green Bay, WI	76	89	313	478
Milwaukee, WI	2,621	89	287	2,997
Calumet Hbr., IN-IL	13,046	183	688	13,917
Indiana Hbr., IN	5,568	214	1,106	6,888
Burns Waterway, IN	1,254	147	524	1,925
Gary, IN	2,948	172	768	3,888
Escanaba, MI	819	385	1,618	2,822
Ludington, MI	5	1	0	6
Port Washington, WI	23	100	303	426
Saginaw, MI	10	0	0	10
St. Clair, MI	983	127	452	1,562
Detroit, MI	23,320	401	1,920	25,641
Alpena, MI	19	6	19	44
Toledo, MI	8,097	240	665	9,002
Sandusky, OH	856	268	0	1,124
Huron, OH	3,239	166	421	3,826
Lorain, OH	4,419	141	638	5,198
Cleveland, OH	21,028	438	1,896	23,362
Ashtabula, OH	3,019	218	722	3,959
Conneaut, OH	5,225	313	1,225	6,763
Buffalo, NY	17,298	444	1,283	19,025
Monroe, NY	944	122	385	1,451
Muskegon, MI	0	13	53	66
TOTAL SYSTEM BENEFITS	$175,022	$7,405	$23,239	$205,666

TABLE 44
TOTAL ANNUAL COSTS FOR HARBORS IN RECOMMENDED PLAN
(IN $1,000 at 7-1/8%)

	Total System Average Annual Benefits	Benefits From Season Extension on Upper 4 Lakes Alone: Average Annual Benefits	Benefits From Season Extension on Upper 4 Lakes Alone: Portion of Total Benefits	Added Benefits From Season Extension on Entire GL/SLS System: Average Annual Benefits	Added Benefits From Season Extension on Entire GL/SLS System: Portion of Total Benefits	Upper 4 Lakes Cost $37,293	St. Law Riv Cost $6,081	Individual Harbor Annual Costs	Total Annual Harbor Costs
Two Harbors, MN	$ 5,488	$ 5,488	.0450	$ 0	.0000	$ 1,678	$ 0	$ 0	$ 1,678
Duluth-Superior MN-WI	52,425	37,222	.3048	15,203	.1820	11,367	1,106	1,790	14,263
Presque Isle, MI	1,703	1,690	.0138	13	.0002	515	1	0	516
Marquette, MI	159	159	.0013	0	.0000	48	0	144	192
Taconite, MN	5,640	5,640	.0462	0	.0000	1,723	0	0	1,723
Silver Bay, MN	5,623	5,623	.0461	0	.0000	1,719	0	25	1,744
Ashland, WI	250	226	.0019	24	.0003	71	2	595	668
Green Bay, WI	478	478	.0039	0	.0000	145	0	228	373
Milwaukee, WI	2,997	455	.0037	2,542	.0304	138	185	0	323
Calumet Harbor, IN-IL	13,917	1,935	.0158	11,982	.1434	589	872	380	1,841
Indiana Harbor, IN	6,888	2,346	.0192	4,542	.0544	716	331	153	1,200
Burns Waterway, IN	1,925	1,383	.0113	542	.0065	421	40	0	461
Gary, IN	3,888	1,747	.0143	2,141	.0256	533	156	0	689
Escanaba, MI	2,822	2,817	.0231	5	.0001	861	1	709	1,571
Ludington, MI	6	5	.0000	1	.0000	0	0	401	401
Port Washington, WI	426	426	.0035	0	.0000	131	0	0	131
Saginaw, MI	10	0	.0000	10	.0001	0	1	538	539
St. Clair, MI	1,562	1,562	.0128	0	.0000	477	0	0	477
Detroit, MI	25,640	6,707	.0549	18,933	.2266	2,047	1,378	0	3,425
Alpena, MI	44	40	.0003	4	.0000	11	0	279	290

Table 44 (Cont'd)

	Total System Average Annual Benefits	Benefits From Season Extension on Upper 4 Lakes Alone: Average Annual Benefits	Benefits From Season Extension on Upper 4 Lakes Alone: Portion of Total Benefits	Added Benefits From Season Extension on Entire GL/SLS System: Average Annual Benefits	Added Benefits From Season Extension on Entire GL/SLS System: Portion of Total Benefits	Upper 4 Lakes Cost $37,293	St. Law Riv Cost $6,081	Individual Harbor Annual Costs	Total Annual Harbor Costs
Toledo, OH	$ 9,002	$ 5,251	.0430	$ 3,751	.0449	$ 1,604	$ 273	$ 134	$ 2,011
Sandusky, OH	1,124	237	.0019	887	.0106	71	64	594	729
Huron, OH	3,826	3,467	.0284	359	.0043	1,059	26	322	1,407
Lorain, OH	5,198	4,619	.0378	579	.0069	1,410	42	339	1,791
Cleveland, OH	23,361	8,376	.0686	14,985	.1794	2,558	1,091	244	3,893
Ashtabula, OH	3,959	3,566	.0292	393	.0047	1,089	29	360	1,478
Conneaut, OH	6,763	6,043	.0495	720	.0086	1,846	52	376	2,274
Buffalo, NY	19,025	13,096	.1073	5,929	.0710	4,002	431	417	4,850
Monroe, MI	1,451	1,451	.0119	0	.0000	444	0	273	717
Muskegon, MI	66	66	.0005	0	.0000	19	0	386	405
TOTAL	$205,666	$122,121	1.0000	$ 83,545	1.0000	$37,293	$6,081	$8,687	$52,061

In order to determine what percent of system costs (improvements that are not in a specific harbor but are on the Great Lakes, the St. Lawrence River, or the connecting channels and locks) should be allocated to each of the major harbors, the total annual benefits accruing to each harbor (Table 43) were examined to determine whether they originated from season extension on the upper four lakes alone or from extension on the entire GL/SLS System. Season extension on the upper four Great Lakes principally benefits iron ore and coal bulk cargo movements to and from harbors located on these four lakes. On the other hand, season extension on the entire GL/SLS System additionally benefits overseas general cargo and grain movements to and from specific Great Lakes harbors. A harbor should only share in the cost allocation for those system improvements that it benefits from. For example, if a harbor does not benefit from season extension on the St. Lawrence River, then the cost system improvements on the St. Lawrence River should not be allocated to it.

Table 44 shows (1) the total annual benefits which accrue to each harbor from season extension on the upper four Great Lakes above, and (2) the additional annual benefits which accrue to each harbor from season extension on the entire GL/SLS system. The percent of benefits which accrue to each harbor from season extension on the upper four Great Lakes, and from season extension on the entire GL/SLS System, were applied to the total annual cost of improvements on the four upper lakes and improvements on the Welland Canal/Lake Ontario/St. Lawrence River, respectively. The result was the estimated allocation of annual costs to individual harbors stemming from system improvements on both the four upper Great Lakes and on the Welland Canal/Lake Ontario/St. Lawrence River. The annual system costs allocated to harbors were then added to the annual costs of improvements in the individual harbors themselves (as depicted in Appendix B) to derive total annual harbor costs for the proposed plan.

A comment has been received that the projected increases in general cargo for the recommended plan would require additional harbor facilities in order to handle the additional cargo. Industry has indicated, through the shipper interview survey conducted as part of the Great Lakes Traffic Model development, their desire to participate in the extended season program. This implies that they would construct any harbor facilities necessary to accommodate extended season traffic. Any harbor-side facilities, such as docks, are self-liquidating costs and are not part of project cost and their installation could be handled through permits and environmental statements for that action. Any on-shore secondary development and environmental safeguards (emissions, etc.) would be handled under existing county, State, and Federal regulatory provisions.

Harbor Benefit/Cost Ratios

A summary of the estimated annual benefits, the annual costs and the ratio of benefits to costs for each of the major Great Lakes harbors benefiting from the recommended plan to extend the navigation season is shown in Table 45. Only those harbors with a benefit/cost ratio greater than 1.0 are economically justified.

Benefit/Cost Ratio of Recommended Plan - Excluding Harbors Unjustified From a Federal Investment Viewpoint

If only those 24 harbors with a benefit/cost ratio greater than 1.0 (as shown in Table 45) are included in the recommended plan, then the overall annual benefits of the recommended plan decrease from $205,666,000 to $205,131,000, and the overall annual costs decrease from $52,061,000 to $49,566,000. Therefore, the net effect on the benefit/cost ratio of the recommended plan from exclusion of these harbors is to increase the B/C ratio from 4.0 to 4.1. It should be noted that the decrease in benefits that results from the exclusion

TABLE 45

AVERAGE ANNUAL BENEFITS AND COSTS
FOR U.S. HARBORS IN RECOMMENDED PLAN
(in $1,000 at 7-1/8%)

	Harbor Annual Benefits	Harbor Annual Costs	Benefit/Cost Ratio
Two Harbors, MN	$ 5,488	$ 1,678	3.3
Duluth-Superior, MN-WI	52,426	14,263	3.7
Presque Isle, MI	1,703	516	3.3
Marquette, MI	159	192	0.8
Taconite, MN	5,640	1,723	3.3
Silver Bay, MN	5,623	1,744	3.2
Ashland, WI	250	668	0.4
Green Bay, WI	478	373	1.3
Milwaukee, WI	2,997	323	9.3
Calumet Hrbr., IN-IL	13,917	1,841	7.6
Indiana Harbor, IN	6,888	1,200	5.7
Burns Waterway, IN	1,925	461	4.2
Gary, IN	3,888	689	5.6
Escanaba, MI	2,822	1,571	1.8
Ludington, MI	6	401	0.0
Port Washington, WI	426	131	3.3
Saginaw, MI	10	539	0.0
St. Clair River, MI	1,562	477	3.3
Detroit, MI	25,641	3,425	7.5
Alpena, MI	44	290	0.2
Toledo, OH	9,002	2,011	4.5
Sandusky, OH	1,124	729	1.5
Huron, OH	3,826	1,407	2.7
Lorain, OH	5,198	1,791	2.9
Cleveland, OH	23,362	3,893	6.0
Ashtabula, OH	3,959	1,478	2.7
Conneaut, OH	6,763	2,274	3.0
Buffalo, NY	19,025	4,850	3.9
Monroe, MI	1,451	717	2.0
Muskegon, MI	66	405	0.2
TOTAL SYSTEM BENEFITS	$205,666	$52,061	4.0

of these currently unjustified harbors stems from two factors: (a) the elimination of the benefits accruing to the economically unjustified harbors, and (b) the elimination of the benefits accruing to those harbors that trade with the economically unjustified harbors. It is also important to note that the reapportionment of annual benefits and costs to the 24 remaining harbors does not result in any additional harbors becoming economically unjustified.

The harbors listed in Table 45 with benefit/cost ratios of less than unity have been left in the analysis thus far because they have the potential for taking advantage of an extended shipping period. These harbors do ship and receive the season extension sensitive type commodities. However, if these harbors are found to be unjustifiable, from a Federal investment viewpoint, during the Phase I General Design Memorandum stage, they will then be eliminated from the analysis. Of the infeasible harbors, four (Muskegon, Ludington, Alpena, and Saginaw, Michigan) have been planned with Federal investment. Muskegon, Ludington, and Saginaw Harbors would require one ice boom each, and Alpena and Saginaw Harbors would require the installation of navigation lights. These items would be required if these harbors were utilized extensively during the winter period. Therefore, to be very conservative, the Federal cost for these harbors is included. It should also be kept in mind that, potentially, other harbors could benefit from an extended season. If local (Non-Federal) interests for these harbors expect that they could benefit and are willing to pay the total cost of those features needed to take advantage of an extended shipping season, they may do so.

COST SHARING WITH CANADIAN GOVERNMENT

In deriving the United States costs two assumptions were made: for the St. Lawrence River the U.S. would pay 100% of all improvements solely within the U.S. territorial boundaries, as well as 50% of the total cost of improvements bridging the international

boundary. Conversely, it is assumed that Canada would pay for 100% of all improvements solely within its own territorial boundaries, as well as 50% of the total cost of improvements bridging the international boundary, and (2) for the St. Clair River - Lake St. Clair - Detroit River System, the U.S. would pay 50% of all ice control structures and compensating works required within the system. It should be noted that this U.S./Canada cost split is an initial assumption and is subject to negotiations between the American and Canadian governments.

For purposes of sensitivity analysis, a benefit/cost ratio can be prepared for the recommended plan which shows the impact of the U.S. paying the entire cost of improvements in international sections of the navigation system. The resulting B/C ratio, 3.5, indicates that the feasibility of the project is not at all dependent on the 50-50 cost split assumption made above. This holds when isolating the benefits and costs of extension on the St. Lawrence River portion of the system, as broken out in Table 44.

To complete the analysis of incremental extension of the navigation season, full twelve month operation on the upper Great Lakes and on the St. Lawrence Seaway must be examined. This would involve extending the operating season an additional two months, on the St. Lawrence Seaway, beyond the Recommended Plan. This option was not analyzed in detail because of the high cost of twinning the seaway locks to avoid closing for maintenance at some point during the year. Major structural modifications to the system are not included in the scope of this study, nor would the expense be justified by the incremental benefits gained in the context of season extension alone.

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APPENDIX E

GL/SLS ENVIRONMENTAL PLAN OF ACTION

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

1.1 Background

The Great Lakes-St. Lawrence Seaway Navigation Season Extension Program (Extended Season Program) was authorized by the Congress in the River and Harbor Act of 1970 (Section 107, Public Law 91-611). Presently, navigation within the Great Lakes-St. Lawrence Seaway system essentially ceases between mid-December and early April. Extended winter navigation would be possible through a combination of ice-breaking activities, ice reduction, bubblers, ice stabilization booms, improved winter navigational aid systems and channel modifications including channel widening and partial flow control systems. The purpose of the Extended Season Program is to determine the economic, environmental and engineering feasibility of extending the navigation season and determine if there is a Federal interest in assisting such an effort. This Survey Report for the Extended Season Program includes alternatives, recommendations and plans for implementation. The complexity of the environmental problems and the lack of suitable data to evaluate many potential environmental problems and concerns, necessitates that environmental studies be conducted during the pre-construction and early implementation period so that environmental impacts of winter navigation activities can be fully assessed, measured and evaluated.

The Environmental Plan of Action is based on the principle that the Extended Season Program would be modified and, if necessary, a moratorium on Program activities would be put in effect if unacceptable environmental impacts are encountered. These unacceptable environmental impacts could be identified during any of the post-authorization phases including design studies, construction or operation. The intent is to identify as many impacts as possible during Phase I of the design studies.

The Division Engineer, North Central Division, Corps of Engineers (COE), requested the Regional Director, Great Lakes Region, U.S. Fish and Wildlife Service (FWS), to prepare an Environmental Plan of Study. The FWS assembled five Environmental Planning Task Force Teams to identify concerns and needed studies. Citizens and scientists provided extensive input. The FWS completed the initial plan, termed the Interim Environmental Plan of Study (EPOS), in March 1978. The Interim EPOS included more than 400 environmental concerns and suggested studies by scientists, Federal and State natural resource managers, private citizens and citizen organizations.

The following statement taken from the Interim EPOS (Future Action, page 65) sets the need and scope for the development of the Environmental Plan of Action:

> "In many ways, the EPOS development process described above in Section 2.0 represents a "brainstorming" effort which, through participation by many individuals and organizations, has devised a master list of environmental

concerns and studies to address those concerns. Ordinarily, the product of a brainstorming effort is unconstrained by external scheduling or quality control considerations and requires subsequent revision to make it a workable entity. In its current state, the EPOS has evolved well beyond a brainstorming document since considerable attention has already been focused on reviewing the study proposals and linking activities. Nonetheless, considerable refinement will be required to hone the EPOS to an efficient study plan and implementation package."

The four primary goals of the Interim EPOS were to determine:

1. What studies need to be undertaken?

2. Where will the studies be undertaken?

3. Who should do them?

4. How much will they cost?

These questions were partially addressed in the Interim EPOS. The COE and FWS determined that the Interim EPOS should be refined and developed into an Environmental Plan of Action (EPOA). The purpose of the EPOS is to aid in conserving the environmental attributes of the Great Lakes system impacted by the Extended Season Program. The products of the EPOA will be reports describing the findings of the proposed studies and recommendations to eliminate or minimize the adverse effects of the project on the resources.

The assessments and studies outlined in the EPOA are of the impacts of the project on the natural environmental resources, both physical and biological, including fish and wildlife. The studies and assessments of the EPOA do not include the effects of the project on socio-economic aspects of the area, though these are impacted by the project and likely by the implemented recommendations of the studies. The socio-economic aspects interrelate with the natural environment by using the resources and by displacing them. The EPOA assessments and studies also do not include the institutional, cultural and aesthetic aspects of the project though aspects also interrelate with the natural environment.

The EPOA includes methods for assessing environmental impacts, studies to be conducted, and estimates of study costs. The EPOA also includes an integrated environmental study and engineering schedule, the outline of a system for managing data, and a description of an overall system for selecting and scheduling studies that the needed information would be available at a suitable time for environmental assessment and planning. The EPOA would be refined throughout the Extended Season Program as new information and insights are gained.

The EPOA is to be considered a dynamic document open to change and updated as deemed necessary. Toward this end, an environmental assessment team, "Environmental Assessment of the Great Lakes Ecosystem" (EAGLE) has been organized by the FWS. The function of EAGLE shall be to refine the EPOA and make specific recommendations for studies to the Corps of Engineers which it considers essential to an understanding of the environmental impacts of winter navigation.

1.2 Problem Statement

The region considered under the Extended Season Program is the United States portions of the Great Lakes system. These portions of the system include the international waters under the jurisdiction of the United States and it is assumed that all references in this report refer to these U.S. portions only. This system includes the five Great Lakes with their interconnecting waterways and the St. Lawrence River. It extends 2,342 miles from the western end of Lake Superior to the sea, of which 1,270 miles are within the five Great Lakes.

The Extended Season Program would directly affect the following areas of the system: (1) navigation channels, both interlake and the St. Lawrence River; (2) harbors; (3) locks; and, (4) open lake transportation lanes. Winter navigation activities would include: (1) improved winter navigation aids; (2) structural booms to control ice movement; (3) bubbler structures to prevent heavy ice build up in harbors, vessel turning areas, rivers and locks; (4) ice breaking to keep channels and harbors open; (5) dredging of rivers and harbors; (6) compensating works; (7) moving ships; and, (8) erosion and shore structure damage control measures.

It was recognized during the early stages of studying the feasibility of extended winter navigation, that it would not be possible to prepare an Environmental Impact Statement for the Survey Report that would identify or predict all specific impacts because of the insufficient environmental data and detailed engineering design information. To resolve this problem, predictive environmental assessment and planning would be conducted as an on-going activity with engineering planning and construction activities.

There is an extensive data base on certain portions of the Great Lakes environments, but meager information exists on ecological conditions during winter or on the expected impacts of the Extended Season Program. Substantive environmental data have not been gathered on similar navigation programs in the United States or other countries. Implementation of the EPOA would provide the necessary information.

An understanding of how environmental data and assessment would be integrated into planning, engineering, construction and operations can be developed from following the planning, engineering and development modes. Various activities (e.g., installation of bubblers, dredging) would be implemented as follows: (1) initial planning may require 3-5 years and would result in a Phase I General Design Memorandum (GDM); (2) detailed engineering may require 2-4 additional years and results would be described in the Phase II GDM; and, (3) construction and/or operation of the activity would then be implemented. Detailed environmental impact assessment and prediction would be made during the early stages of preparing the Phase I GDM. A detailed Environmental Impact Statement (EIS), incorporating the assessment information, would be prepared to accompany each Phase I GDM.

To accumulate the great amount of necessary information during a relatively short period will require a great effort by many people. The Corps of Engineers and the Fish and Wildlife Service would administer this work. But the work would be accomplished through Interagency Agreements with in-house branches and other Federal agencies; agreements with States; and contracts with universities, private research corporations and consultants. Handling such a bulk of information should be accomplished with computers and data storage banks.

This appears to be the means that extensive information could be available to prepare an adequate impact assessment early in Phase I. Additional assessments would be made throughout all stages of the project, should the initial assessments indicate a need. During the construction and operational periods, data would be collected to monitor and verify predicted effects. Finally, the total effect would be evaluated and a validation report written. If unacceptable environmental impacts are identified during the assessment or evaluation processes, any offending activity would be halted and/or modifications would be implemented to eliminate, modigy or mitigate the actions. It may require 10-15 years from initial planning of an activity to final evaluation.

Site-specific and system-wide impacts must be assessed, and the effects predicted and verified. Site-specific impacts are those that influence a specific harbor or river reach. System-wide impacts are those affecting a lake system, connecting channel system or the entire Great Lakes system.

2. GOALS AND OBJECTIVES

2.1 Goal

The goal of this EPOA is to prescribe an environmental plan for studying project effects on the physical and biological resources of the environment. The results and recommendations of these studies, if implemented, would minimize or eliminate and mitigate or compensate for environmental damages from extending the winter navigation season on the Great Lakes System. The information also would be used to enhance the environmental quality, where possible and provide a base for the assessment of project actions.

2.2 Objectives

The objectives of this document are to:

1. Recommend a method of studying the effects of winter navigation on environmental resources and strive to allay the concerns expressed in the Fish and Wildlife Report (Appendix G) and by the public (Appendix C).

2. Describe, in sufficient detail, the studies and methodology needed for impact assessment, and for monitoring and measuring the effects of construction and operational activities.

3. Provide an estimate of costs of these studies.

4. Describe how studies could be integrated and scheduled into project planning, engineering, construction and operations.

5. Describe a program and data management system for the studies.

3. ENVIRONMENTAL ASSESSMENT

3.1 Perspective on Environmental Assessment

Traditionally, environmental impact assessments and/or studies of project effects strive to evaluate biological, physical, and developmental information and develop preconstruction predictions concerning the consequences of a project on various resources, including fish and wildlife. Preconstruction planning now emphasizes:

1. Alternative development options to avoid undesirable consequences.

2. Inventories and base condition studies necessary to measure environmental changes with and without the project.

3. Means to enhance environmental resources.

4. Means to mitigate and/or compensate for damaged or lost resources.

Historically, evaluations and assessments are performed during the preconstruction phase with minimal modification of plans after the development is implemented. The success of management plans depends heavily on the quality of the assessments. The consequence of a faulty assessment is an inadequate management plan, which frequently leads to environmental mismanagement. The complexity of the Extended Season Program, the variety of potentially influenced environmental resources, and the great geographic scale of the Great Lakes system portend a difficult assessment task.

3.2 FWS Adaptive Environmental Assessment Technique

The FWS Adaptive Environmental Assessment technique stresses the accommodation of impact uncertainties that could contribute to assessment failures. It reduces planning dependency on preconstruction impact predictions and places increased emphasis on responding to impact uncertainties as they occur during project construction and operations. The principles of this alternative environmental assessment approach are described in a book entitled "Adaptive Environmental Assessment and Management."* This technique mobilizes available data and information from subject matter specialists and published and unpublished sources. This is done in order to aggregate and organize those pieces of knowledge which provide insight and definition to the variables and indicators of performance which are reflected in the system.

Initial activities in this technique assembles groups of experts into an "experimental laboratory" setting that: (1) systematically examines processes that could cause recognized and suspected conflicts; (2) converts this information into descriptive and analytical methodologies; and, (3) designs assessment strategies and management outlines. This technique should provide for better management responses to anticipated but unquantified adverse environmental impacts which could occur during the development of the Extended Season Program.

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*C.S. Hollings, "Adaptive Environmental Assessment and Management," John Wiley and Sons, 1978.

A second part of the technique is to search out and synthesize impact information from development projects similar to those proposed for the Extended Season Program. These would augment the information from the "experimental laboratory."

Assessment strategies and management outlines would guide the design of environmental studies (base condition, inventories, monitoring, and evaluation) to be conducted. The experimental laboratory technique could be used to refine the initial set of environmental studies by gathering and processing additional resource and disturbance information in order to more fully anticipate all adverse environmental impacts. These refined environmental data would be used to focus the attention of subsequent sets of environmental studies on these possible impacts. The two portions of the environmental studies which contribute information to the project environmental assessment are: (1) base condition and inventory studies to determine the general distribution and condition of environmental resources and ecological relationships; and (2) monitoring and evaluation studies during the construction and early operation phases.

Both baseline and monitoring type studies are an integral part of this approach and are used to determine the general nature of what is taking place within the system. By increasing the resolution or focus of these studies over time, a concerted effort is made to avoid collecting unusable data while keeping alert to that which has not been studied. Preliminary assessments in preparation for the full-scale baseline studies are currently being conducted through the FWS and COE for the purpose of evaluating the need for certain baseline and monitoring studies. Appropriate representative agencies and groups and individuals including EAGLE would have the opportunity to review and comment on these assessments. Studies found to be unneeded by these preliminary assessments will be eliminated from the environmental assessment program.

Early baseline studies are recommended to serve as a series of individual "search lights" focusing on specific parameters within the context of the system. These studies also serve, by analogy, as a group of strategically placed "fire alarms" to provide decision makers with the earliest possible warning of unanticipated environmental trends and relationships. This early warning capability, in turn, provides the flexibility to redirect updating baseline study efforts in key areas and permits decision makers to exercise a variety of options (e.g., modification, substitution or alternative choices). Thus, this precludes much of the "crisis" or "reactive" management modes which might otherwise be encountered. To identify or classify the dynamics of the system, a range of study frameworks is required. These frameworks include site-specific, cumulative, system-wide and induced effects. Study priorities evolved within these frameworks will be refined with time and need.

Since all impact assessment techniques are reliant on the organization of individual perceptions of the "real world," emphasis is placed by the technique on developing mechanisms to identify and fill key gaps in knowledge. The effective use of an early warning system is dependent on the capability of the system to focus on the correct parameters and to attribute deviations to the proper causes. Refinements in the design of the environmental studies made possible by the collection and processing of additional resource and disturbance data will increase these capabilities of the warning system. However, because of the complexities of the natural system, all impact uncertainties cannot be eliminated by the warning system, especially with respect to attributing deviations to their proper causes.

One mechanism that will be used in conducting the Adaptive Environmental Assessment technique is Ecosystem Analysis (Characterization) Studies. An Ecosystem Analysis (Characterization) Study synthesizes existing information and data; identifies ecological components, processes, and functional relationships; presents information and data in models, narratives, and maps; and relates the information and data to problems encountered in the Extended Season Program impact assessment and planning. The main objective of a characterization is to establish a foundation upon which project impacts including modifications to the ecosystem can be predicted. It also identifies additional data needs and recommends specific priority study needs. At present, a total of 16 of these types of studies are planned for the entire Great Lakes System.

The environmental information gained from these studies will assist in the design of environmental studies. Consequently, the ecosystem studies should be completed prior to initiation of the baseline studies so that the information can be used in the baseline studies.

Since policies, statutes and goals, as well as environmental parameters, frequently change over time and with circumstances, it is apparent that a platform for providing and weighing alternatives is required. Successful decision makers rely on numerous inputs and perspectives before arriving at decisions. Contending alternatives must, therefore, be advocated and compared in order to be considered. Thus, the purpose of the Adaptive Environmental Assessment technique is to identify conflicts and options before decisions are made.

3.3 Initial Application of the Technique

The U.S. Fish and Wildlife Service has performed the initial phases of the described Adaptive Environment Assessment procedures. Three workshops were conducted in late 1978 to synthesize, clarify, and organize information relevant to developing priorities for environmental studies. Experts were brought together in these multi-discipline workshop settings to systematically examine processes that might cause recognized or suspected environmental conflicts. In this way, the large number of variables involved in the environmental system were compressed into an organizable framework from which the important features of the system could be defined. Information collected at these workshops were manipulated through a series of tables and diagrams to obtain priority lists of sites and areas requiring environmental studies. These priority lists are extremely useful in determining the location and character of environmental studies.

The first workshop (called the Management Workshop) gathered information on environmental resources that are being managed by state or federal management plans. The primary intent of this workshop was to ensure that resources most valuable to state and federal agencies (implied by the existence of a management plan) would be included in the structuring of the environmental studies and thus would receive due consideration in the environmental assessment. Substantial management plan information was obtained for the states of Minnesota, Wisconsin, Michigan, and Ohio. The management information basically includes the names of species covered by agency management plans, the geographic delineation of the life history or life requirement features for each species, the most important ecological features upon which the species' welfare is dependent, and the nature of the management action.

The second workshop (called the Physical Dynamics Workshop) gathered information on thirteen basic physical disturbances that could result from the act:..ies of the Extended Navigation Program. This information covered all of the U.S. portions of the lakes, connecting rivers, and the St. Lawrence River. The information basically includes a geographic delineation of areas that would be included in physical disturbances.

The third workshop (called the Biological Workshop) collected basically the same kinds of information as collected in the management workshop, but this information was not necessarily associated with management plans and thus represents a more general ecological perspective.

It is realized that the information collected from these three workshops is incomplete and must be augmented with additional information as the program progresses. Current information does not represent a framework that will provide studies to detect and quantify all or perhaps even a majority of detailed impacts that will occur. However, the information does represent a sufficient spectrum of environmental resources, physical disturbances, management actions, and geographic areas to provide an initial set of environmental studies that will indicate general patterns and magnitudes of environmental impact.

The workshop results, along with information obtained from published sources, were manipulated through a series of matrices and through a computerized spatial analysis system. The results include an immediate perspective on the recognized and potential relationships among physical disturbances, management plans, and environmental resources (all within specifically designated geographic areas). This spatial documentation allows for the rapid review of the system for potential conflicts or surprises, limited, however, by the quality and extent of the data.

The resource information gathered through the workshops was first organized into species-dependency tables. These tables contained the species names or environmental features of concern, the specific environmental components upon which they ultimately depend for their welfare of livelihood, and the names of the sites or areas where the species or features are located. Also included was a unique index number that identifies the map that delineates the location and spatial extent of species, features, and life requirements. The principal purpose of the species-dependency tables was to provide a summary of the site-specific environmental resources that were used in following condensations and analyses.

Resource information from the species-dependency tables was combined into a number of site-specific species component diagrams. These diagrams consisted of a simplified network of compartments containing the most commonly discussed ecological components and dependencies among the components. Physical disturbances identified in the Physical Disturbance Workshop for each site or area were displayed in the species-component diagrams.

The first purpose of the species component diagrams was to provide the analysis with an ordered format that was sufficiently detailed to accommodate the workshop details and yet sufficiently general to summarize and illustrate the major implications of the workshop information. The second purpose of the species component diagrams was to provide a mechanism for illustrating the environmental components that were likely to be influenced by physical disturbances.

The intention of illustrating the environmental components and physical disturbances in the species component diagrams was to provide an initial stratification of sites and areas into an importance hierarchy; importance implying the relevant need for inclusion in the environmental studies. Four levels of importance resulted for sites and areas. These four levels of importance are based in descending order as follows: (1) sites with high disturbance and resource ratings; (2) sites with high resource and low disturbance ratings; (3) sites with low resource and high disturbance ratings; and, (4) sites with low resource and low disturbance ratings. These levels of importance were used as the priority rankings in Table 3 of sites and areas for study.

The information of the species component diagrams was consolidated into disturbance site component diagrams. Seventy-eight known or potential disturbance sites were identified from information provided by the species-component diagrams and winter navigation literature. A disturbance site component diagram was prepared for each of the seventy-eight disturbance sites and each represented a summary of all information contained in all of the species component diagrams whose geographic area of occurrence fell within a zone of influence around the disturbance site. Generally, this zone of physical disturbance was set at 2-3 miles over water and up to ½ miles over land.

The disturbance sites were divided into four levels of suggested environmental study priorities. Priorities were based on disturbance rating and the resource ratings provided by the species component diagrams. The disturbance ratings were either high or low, based upon the sum of the number of winter navigation activities proposed for the site and the number of physical disturbance compartments implicated with the proposal activities or identified during the physical workshop.

An alternative set of priorities was developed by substituting high and low traffic estimates (i.e., the estimated ship visits per winter by the year 2000 to each site) for high and low disturbance ratings.

Disturbance site rankings resulted from the two methods of prioritizing geographic areas of impact and natural resource values. Table 3 shows the results of the initial application of this assessment technique, including the site and area names, the project activities at each site or area, and the priority ranking of each site or area for both ranking methods. These site rankings should be a basic consideration in defining the spatial scope of environmental studies.

A necessary set of companion information to the disturbance-site ranking is a definition of the biological resources that occur in each disturbance area. Lists of the biological resources that occur in the highest priority disturbance sites were developed to accompany each site. These listed components, and further compressed lists, should receive foremost attention in defining environmental studies in the highest priority areas, and in other areas if deemed necessary.

A second set of companion information to the disturbance-site rankings is a definition of the management actions that occur in each disturbance area. These management actions include navigation program activities and traffic volumes. Lists were generated of the management actions that will probably occur in each disturbance site in order to aid in the definition of environmental studies.

Table 3.

Disturbance Site Rankings

Site Number	Site Name and State		1 Water Quality Problem	2 Air Bubblers	3 Ice Booms	4 Dredging	5 Mooring Facilities	6 Navigation Aids	7 Compensating Works	8 Ice Breaking	9 Traffic Volume	10 Ranking by Method 1	11 Ranking by Method 2
1	Two Harbors	MN									114	4	3
2	Duluth-Superior	MN	X	2			1	6		X	589	1	1
3	Presque Isle	MI									57	1	1
4	Marquette	MI		1			1				23	1	2
5	Taconite	MN									216	3	3
6	Silver Bay	MN	X	1							181	3	3
7	Ashland	WI		1						X	8	1	2
8	Green Bay	WI	X							X	84	1	1
9	Milwaukee	WI	X				2				479	3	3
10	Calumet	IL		1							644	3	3
11	Indiana Harbor	IN			1						296	3	3
12	Burns Waterway	IN									67	4	3
13	Gary	IN									118	4	3
14	Escanaba	MI		1			1			X	212	1	1
15	Ludington	MI			1					X	597	3	3
16	Port Washington	WI									34	4	4
17	Saginaw	MI			1					X	28	4	4
19	Detroit	MI	X				2				374	1	1
20	Alpena	MI		1			7	1		X	27	1	2
21	Calcite	MI		1						X	6	3	4
22	Toledo	OH	X				1	1		X	748	3	3
23	Sandusky	OH	X	1						X	100	1	1
24	Huron	OH	X	1	1					X	50	1	2
25	Lorain	OH			1						226	3	3
26	Cleveland	OH	X		1		1				447	1	1
27	Ashtabula	OH	X		1						152	3	3
28	Conneaut	OB	X		1						125	3	3
29	Buffalo	NY	X		1					X	179	3	3
30	Monroe	MI		1						X	50	3	4
31	Oswego	NY	X		1		1				9	1	2
32	Rochester	NY					1				3	2	2
33	Muskegon	MI			1					X	195	1	1
34	Erie	PA		1			2			X	8	3	4
35-44	St. Mary's River			6		6		1		X	1327	1	1
36	Sault Ste Marie	MI					3		1		17	1	2
45	St. Clair R. - Stag Is.		X						1		2172	1	1
46	St. Clair R. (head)		X		1						2172	1	1
47	Detroit R. - Peach Is.		X		1				1		2172	1	1

Table 3. (Continued)

Disturbance Site Rankings

i			1	2	3	4	5	6	7	8	9	10	11
48	St. Law. R. - Ogden - Iroq.		X		9						809	1	1
49	Saginaw Bay Proper				1			2		X	37	1	2
50	Green Bay Proper							4		X	554	1	1
51	St. Law. R. - Iroq. - Merris		X		3	1					809	1	1
52	Chicago	IL					1				99	4	3
53	Bay City	MI					?			X	9	4	4
54	St. Ignace	MI					2				?	2	2
55	Traverse City	MI					?				32	4	4
56	Sturgean Bay	WI					1				?	1	2
57	Ogdensburg	NY					1				?	2	2
58	Cape Vincent	NY					1				?	2	2
59	Kewaunee	WI								X	408	2	1
60	Washburn	WI									2	1	2
61	Drummond Is.	MI									11	4	4
62	Post Is.	MI									2	4	4
63	Gladstone	MI									14	2	2
64	Washington Is.	WI									216	2	1
65	Gills Rock	WI									28	2	2
66	Manitowac	WI								X	189	4	3
67	Sheboygan	WI									5	2	2
68	Racine	WI									12	4	4
69	Waukeegan	IL									8	4	4
72	St. Joseph	MI									7	4	4
73	Ferrysburg	MI									2	2	2
74	Frankfort	MI									200	2	1
75	Northport	MI									186	4	3
76	Charlevoix	MI					?				8	4	4
77	Petoskey	MI									6	2	2
78	Mackinow City	MI								X	2	2	2
79	Cheboygan	MI									18	2	2
80	Stoneport	MI									64	4	3
81	Marine City	MI	X								63	1	1
82	Dearborn/R. Rouge	MI	X								367	1	1
83	Ecorse	MI	X								124	1	1
84	Trenton	MI	X								47	2	2
85	Port Clinton	OH									8	2	2
86	Marblehead	OH									2	2	2
87	Fairport	OH									12	4	4
88	Lachawana	NY									12	4	3
89	Townawanda	NY									2	3	4

4. ENVIRONMENTAL STUDIES

4.1 Background

One of the first steps in the development of the comprehensive environmental studies, described in Attachment C, was an analysis of the numerous studies contained within the Interim EPOS. The important environmental concerns and geographic locations of the studies were listed and compared with the concerns and geographic areas of interest cited in the FWS Coordination Act Report. A similar set of concerns and areas of potential impact were derived from a workshop held in November 1977 at the Great Lakes Fisheries Laboratory in Ann Arbor, Michigan. This information was combined with the results of the initial application of the Adaptive Environmental Assessment technique (described in Section 3) to develop a set of comprehensive studies incorporating all the concerns and all the geographic areas. These comprehensive studies include nearly all parameters suggested for study in the Interim EPOS. This method of development was designed to assure that potential concerns or areas of impact were not overlooked. Table 1 compares the cited concerns with the development activities proposed for the Extended Season Program. Table 2 shows the relationship between the geographic areas of concern and the proposed developments for those areas.

The site-specific studies described in Attachment C were then developed to include all concerns and areas of potential impact and were keyed to the proposed developments. The system-wide studies identified in the EPOS, FWS Coordination Act Report and the Great Lakes Fisheries Laboratory Workshop were consolidated into eleven system-wide studies. These studies include such activities as the location of wetlands and the identification of fish spawning and nursery grounds.

The site-specific studies as described in Attachment C have obvious areas of overlap. The redundancy in baseline and monitoring studies was eliminated by further assessment and refinement of the developments in areas with common environmental settings and similar sampling parameters. Thus, the 121 site-specific studies were consolidated into 71 area-wide studies, and these groupings are described in Attachment B.

4.2 Studies

The Extended Season Program Environmental Studies were originally grouped into two types: site-specific and system-wide. The association between site-specific environmental study locations and their respective proposed developments and actions are presented in Table 2. However, the number of studies at the lakes and connecting channels were further reduced by combining the studies of two or more developments to produce a single baseline inventory (e.g., baseline studies for ice breaking, vessel speed, shoreline protection, and air bubblers were combined in the stretch of the St. Marys River from Whitefish Point to the Soo Locks).

Table 1.

FISH AND WILDLIFE CONCERNS FOR EACH ENGINEERING DEVELOP- MENT OR ACTION

Fish & Wildlife Concerns \ Development & Actions	1.Icebreaking	A.Prop Wash & Power	B.Vessel Track	2.Icebreaker Mooring Fac.	A.Dredging & Spoil Disp.	B.Land Storage Fac.	C.Icebreaking	3.Aids to Navigation	A.Fixed Structure Lights	B.Range Lights	4.Ice Stab. Structures	A.Ice Booms	B.Ice Boom Anchors	C.Change Sewage Outfall	D.Ice Stab. Islands	5.Air Bubblers	A.At Ferry Docks(Flusher)	B.In Channels & Curves	6.Lock Modifications	A.Bubblers	B.Steam	C.Dredging	7.Dredging	A.Channel Widening	B.Spoil Placement	C.Dredging to Red.Currents	8.Compensating Works	A.Water Flow Regulation	B.Structure
I.Physical	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
A.Water Levels	x		x								x	x											x	x		x	x	x	
B.Water Flows (cfs)	x	x	x								x	x		x	x								x	x		x	x	x	
C.Current Patterns	x	x		x	x		x	x	x		x	x		x	x								x	x	x	x	x	x	x
D.Sediment Composition	x	x		x	x		x				x	x	x	x		x	x	x	x			x	x	x	x	x	x		x
E.Sediment Pollution	x	x		x	x		x				x			x		x	x	x					x			x	x	x	
F.Bottom Type	x	x		x	x		x				x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	
G.Water Temperature	x	x									x			x		x	x	x	x		x						x	x	
H.Water Quality	x	x		x	x		x				x		x	x		x	x	x					x	x	x	x	x	x	
I.Oxygen Levels	x	x		x	x		x				x			x		x	x	x	x	x									
J.Shoreline Comp.&Type				x	x	x				x	x				x		x												
K.Erosion Rate	x	x				x	x	x		x	x	x											x			x	x	x	
L.Percent Ice Cover	x	x	x	x	x		x				x	x		x	x	x	x	x					x			x			
M.Ice Ramparting	x	x	x	x	x		x																						
N.Bottom Scour	x	x	x	x	x		x																x			x	x	x	x
O.Ice Jams	x		x					x	x		x	x			x	x	x	x									x		x
II.Environmental	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
A.Fish	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
1.Spawning Habitats	x	x		x	x	x					x	x	x		x								x		x	x	x	x	x
2.Scare Fish	x	x		x	x		x									x	x	x											
3.Loss of Feeding Hab.	x	x		x	x		x				x	x	x	x									x	x		x	x	x	x
4.Loss of Mig.Route	x	x		x			x																						
5.Loss of Wintering Hab.	x	x	x	x	x		x																x	x		x	x		x
6.Lost or Red.Benthos	x	x		x	x	x	x	x	x		x		x	x		x	x	x	x			x	x	x	x	x	x	x	x
7.Turbidity-Abras.&Vis.	x	x		x	x	x	x				x		x	x		x	x	x	x			x	x	x	x	x	x	x	
8.Water Curr.-Too Strong	x	x		x			x																				x	x	
9.Water Temperature	x	x	x													x	x	x	x		x								
10.Direct Mech.Kill	x	x																											
11.Direct Toxic Kill				x	x						x			x									x			x			
12.Eggs Lost-Overwinter	x	x			x		x																						
13.Fishermen Safety	x	x	x	x			x				x	x				x		x											
14.Fishermen Access	x	x	x	x			x				x	x				x		x											
B.Wildlife	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x		x	x	x	x	x	x	x
1.Loss of Cover				x	x	x		x		x													x		x		x	x	
2.Loss of Resting Area	x		x	x			x				x	x		x															
3.Loss of Feeding Area	x	x		x	x	x				x	x	x	x		x								x			x	x	x	
4.Shortstopping	x		x	x	x		x			x	x	x		x		x		x									x		x
5.Lost or Red.Benthos	x	x		x	x		x	x	x		x		x	x	x	x		x					x	x	x	x	x	x	
6.Harrassment	x	x	x	x	x	x	x																						
7.Denial of Mig.Access	x		x	x												x		x											
8.Oiling-Direct Mort.																													
9.Animals Lost in Track	x		x	x			x									x		x											
10.Loss of Nesting Hab.				x	x	x																					x	x	
11.Hunter Access	x	x	x													x		x					x		x	x			
12.Pollution Movement	x	x	x	x	x	x	x									x		x											

Table 1.

FISH AND WILDLIFE CONCERNS FOR EACH ENGINEERING DEVELOPMENT OR ACTION (continued)

Development & Actions \ Fish & Wildlife Concerns	I.Physical	A.Water Levels	B.Water Flows (cfs)	C.Current Patterns	D.Sediment Composition	E.Sediment Pollution	F.Bottom Type	G.Water Temperature	H.Water Quality	I.Oxygen Levels	J.Shoreline Comp.&Type	K.Erosion Rate	L.Percent Ice Cover	M.Ice Ramparting	N.Bottom Scour	O.Ice Jams	II.Environmental	A.Fish	1.Spawning Habitats	2.Scare Fish	3.Loss of Feeding Hab.	4.Loss of Mig.Route	5.Loss of Wintering Hab.	6.Lost or Red.Benthos	7.Turbidity-Abras.&Vis.	8.Water Curr.-Too Strong	9.Water Temperature	10.Direct Mech.Kill	11.Direct Toxic Kill	12.Eggs Lost-Overwinter	13.Fishermen Safety	14.Fishermen Access	B.Wildlife	1.Loss of Cover	2.Loss of Resting Area	3.Loss of Feeding Area	4.Shortstopping	5.Lost or Red.Benthos	6.Harrassment	7.Denial of Mig.Access	8.Oiling-Direct Mort.	9.Animals Lost in Track	10.Loss of Nesting Hab.	11.Hunter Access	12.Pollution Movement
9.Shoreline & Str. Damage	x		x	x	x	x	x		x		x	x			x	x	x	x	x		x			x	x								x	x		x		x					x		x
A.Rip-rap	x		x	x	x	x	x		x		x	x			x		x	x	x		x			x	x								x	x		x		x					x		x
B.Fracture Line Piling	x															x																													
10.Island Transportation	x			x				x		x							x	x									x						x				x								
A.Dock Bubbler	x			x				x		x							x	x									x																		
B.Ice Boom	x			x													x	x									x						x				x								
11.Vessel Speed Cont.&Movem.	x			x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x		x	x	x	x	x		x		x	x	x		x	x		x
A.Surge & Vessel Ind.Waves	x			x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x		x	x	x	x	x		x		x	x	x		x	x		x
12.Vessel Oper.&Design Crit.	x				x	x	x		x		x	x			x		x	x	x		x		x	x	x	x				x	x	x	x			x		x	x			x	x		x
A.Larger Prop. & Engine	x				x	x	x		x		x	x			x		x	x	x		x		x	x	x	x				x	x	x	x			x		x	x			x	x		x
13.Oil & Haz.Substance Spill	x					x			x								x	x	x		x		x	x					x	x			x	x	x	x		x			x		x		x
A.Load.&Unloading Spills	x					x			x								x	x	x		x		x	x					x	x			x	x	x	x		x			x		x		x
B.Ship Fuel Tank Rupture	x					x			x								x	x	x		x		x	x					x	x			x	x	x	x		x			x		x		x
C.Tanker Breakup	x					x			x								x	x	x		x		x	x					x	x			x	x	x	x		x			x		x		x
14.Vessel Waste Disch(Nonhum.)	x								x	x							x	x											x												x				
15.Pilot Access	x			x	x	x	x		x		x			x	x		x	x	x		x		x	x	x					x		x	x	x		x		x	x				x		x
A.Icebreaking	x			x	x	x	x		x		x			x	x		x	x	x		x		x	x	x					x		x	x	x		x		x	x						x
B.Mooring Facilities	x			x		x	x		x		x				x		x	x	x		x			x	x								x	x		x		x	x				x		x
16.Channel Clearing Craft	x	x	x					x		x			x	x		x	x	x		x			x				x						x				x		x	x		x			
17.Harbor Icebreaking	x			x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x			x	x	x	x			x	x	x	x			x			x
A.Prop Wash	x			x	x	x	x	x	x	x		x	x	x	x		x	x	x	x	x		x	x	x	x	x			x	x	x	x			x		x	x						x
B.Vessel Track	x												x	x	x	x	x	x													x	x	x				x					x			
18.Harbor Ice Booms	x			x	x	x			x				x		x	x	x	x	x		x			x	x						x	x	x		x	x		x							
A.Booms	x			x									x		x	x	x	x	x												x	x	x		x	x									
B.Anchors	x				x	x			x								x	x	x		x			x	x								x					x							
19.Harbor Bubblers	x			x		x		x	x	x			x				x	x		x							x				x	x	x				x								x
A.At Docks	x			x		x		x	x	x			x				x	x		x							x						x				x								x
B.In Turning Basins	x			x		x		x	x	x			x				x	x		x							x				x	x	x				x								x
20.Harbor Navigation Aids	x			x													x	x						x									x					x							
A.Fixed Structure Type	x			x													x							x									x					x							

X - Location of Development or Action
● - Location of Development of Concern

Table 2

SITE SPECIFIC ENVIRONMENTAL STUDY LOCATIONS BY ENGINEERING DEVELOPMENT AND ACTION

Location	1.Icebreaking	A.Prop Wash & Power	B.Vessel Track	2 Icebreaker Mooring Fac.	A Dredging & Spoil Disp.	B.Land Storage Fac.	C.Icebreaking	3.Aids to Navigation	A.Fixed Str.Lights	B.Range Lights	4.Ice Stab. Structure	A.Ice Booms	B Ice Boom Anchors	C.Change Sewage Outfall	D Ice Stab. Islands	5 Air Bubblers	A.At Ferry Docks (Flush.)	B.In Channels & Curves	6.Lock Modification	A.Bubblers	B.Steam	C.Dredging	7.Dredging	A.Channel Widening	B.Spoil Placement	C.Dredging to Red.Curr.	8 Compensating Works	A.Water Flow Reg.	B.Structure	9.Shoreline & Str.Damage	A.Rip-rap	B.Fracture-line Piling	10.Island Transportation	A.Dock Bubbler	B.Ice Boom	11.Vessel Sp.Cont.&Movem.	A.Surge&Vessel Ind Waves	12.Vessel Oper.& Des.Crit.	A.Larger Prop & Engine	13.Oil & Haz.Subst.Spills	A.Load.&Unloading Spills	B.Ship Fuel Tank Rupture	C.Tanker Breakup	14.Vessel Waste Disch.(Nonhuman)	15.Pilot Access	A.Icebreaking	B.Mooring Fac.	16.Channel Clearing Craft	17.Harbor Icebreaking	A.Prop Wash & Power	B.Vessel Track	18.Harbor Ice Booms	A.Booms	B.Anchors	19.Harbor Bubblers	A.At Docks	B.Turning Basins	20.Harbor Navigation Aids	A.Fixed Str. Type	Total
Lake Superior:																																				X				2																				2
St. Marys River	●			●							2					7	X	X					●	X						2	X					4	X			2																				20
Silver Bay																																				X																								1
Duluth-Superior	X			●																																●																			●					4
Ashland																																				X													●						●					1
Marquette				●																																X																			●					2
Taconite																																				X																								0
Two Harbors																																				X																								0
Presque Isle																																				X																								1
Lake Michigan:																																				X				2																				2
Escanaba																																				X													●						●					2
Green Bay	●																																			●	X												●											3
Calumet																																				X																			●					1
Indiana																																				X																●								1
Muskegon																																				●													●			●								3
Ludington																																				X													●			●								2
																																				X																								0
Port Washington																																				X																								0
Milwaukee				●																																X																								1
Burns Waterway																																				X																								0
Gary																																				X																								0

X - Location of Development or Action
■ - Location of Development of Concern

Table 2 (Cont.)

SITE SPECIFIC ENVIRONMENTAL STUDY LOCATIONS BY ENGINEERING DEVELOPMENT AND ACTION (cont.)

Location \ Development and Actions	1.Icebreaking	A Prop Wash & Power	B.Vessel Track	2.Icebreaker Mooring Fac.	A.Dredging & Spoil Disp.	B.Land Storage Fac.	C.Icebreaking	3.Aids to Navigation	A.Fixed Str.Lights	B.Range Lights	4.Ice Stab. Structure	A.Ice Booms	B.Ice Boom Anchors	C Change Sewage Outfall	D.Ice Stab. Islands	5.Air Bubblers	A At Ferry Docks (Flush.)	B.In Channels & Curves	6.Lock Modification	A.Bubblers	B.Steam	C.Dredging	7.Dredging	A.Channel Widening	B.Spoil Placement	C.Dredging to Red.Curr.	8.Compensating Works	A.Water Flow Reg.	B.Structure	9.Shoreline & Str.Damage	A.Rip-rap	B.Fracture-line Piling	10 Island Transportation	A.Dock Bubbler	B.Ice Boom	11.Vessel So.Cont.&Movem.	A Surge&Vessel Ind.Waves	12.Vessel Oper.&Res.Crit.	A.Larger Prop & Engine	13.Oil & Haz.Subst.Spills	A.Load.&Unloading Spills	B.Ship Fuel Tank Rupture	C.Tanker Breakup	14.VesselWasteDisch.(Nonhuman)	15.Pilot Access	A.Icebreaking	B.Mooring Fac.	16.Channel Clearing Craft	17.Harbor Icebreaking	A.Prop Wash & Power	B.Vessel Track	18.Harbor Ice Booms	A.Booms	B.Anchors	19.Harbor Bubblers	A.At Docks	B Turning Basins	20.Harbor Navigation Aids	A.Fixed Str. Type	Total
Lake Huron:	X																						X		X											X				2																				2
St. Clair River	■										■																■		X	■	X	X				2	X			3																				9
St. Clair Lake	■																																			■				2																				4
Detroit River	■			■							■																■		X	■	X	X				2	X			2																				9
Alpena				■																																■													■						■					4
Saginaw Bay	■																																			■	X												■			■								4
Drummond Island																																				X																								0
St. Ignace				■																																X																								1
Lake Erie:	■																											X								■				3																				5
Monroe																																				X													■						■					2
Toledo				■																																X													■											2
Sandusky	■																																			■	X																		■					3
Huron																																				X													■			■			■					3
Lorain																																				X																■								1
Cleveland				■																																X																■								2
Ashtabula																																				X																■								1
Conneaut																																				X																■								1
Buffalo																																				X													■			■								2
Lake Ontario:	X																											X								X				3																				3
Oswego				■																																X																■								2
St.Lawrence River:	■										■								X				■		X	X		X		4	X					1	X			1																				12
Ogdensburg				■																																X												■												2
Cape Vincent				■																																X									■		::													2
TOTAL	10			16				0			5					7			0				7				2			::			0			20		0		24				0	1			#13				11			12					131

Refinement of the environmental studies is a continuing process that will be accomplished during all phases and implementation as program plans change and more experience is gained from the program. This process has already been initiated as evidenced by the study combinations identified in Table 4 and Attachment B. This consolidation of study efforts results in considerable savings in manpower and funding.

The system-wide studies found in Attachment C address the more far-reaching effects of the Extended Season Program. Eleven system-wide studies evaluating various aspects of fish and wildlife resources, habitat classification and usage, and water quality are proposed. Because of the extensive amount of data necessary to detect cumulative effects, these studies will be more complex and could require more time than the site-specific studies. Information gathered through these system-wide study efforts would be updated, verified and data gaps identified. If determined to be necessary, crucial gaps in the data would be filled by additional investigations before initiation of either construction or operations.

The ecosystem characterization and analysis studies have been proposed to identify and integrate all of the existing information about a lake or connecting channel system and identify the data gaps. These studies are to be implemented on a geographic basis prior to development in contrast to the site-specific studies which are to be implemented on a project basis. The other ten system-wide studies are oriented toward identification and analysis of specific resources on a systemwide bases. Their purpose is the acquisition of baseline information prior to construction with monitoring of impacts during and after construction.

The following contingencies must be considered with respect to the proposed studies: (1) study cost estimates include the amount of effort needed for the study, program management and overhead; (2) if, during the course of the studies, evidence of significant project adverse effects are observed, that portion of the project responsible would be terminated until the effects are eliminated or minimized through alternate developments or actions; and, (3) study scheduling is based on the beginning of construction or operation. Base condition and inventory information and related evaluations are needed for the preparation of the EIS during the latter part of the Phase I GDM. The gathering and evaluation of environmental information is to continue through the construction phase and on into operation of the program.

Table 4.

ENVIRONMENTAL STUDY COMBINATIONS BY LOCATION

Geographic Area

1. Lake Superior
   - Duluth - Superior
   - Ashland - Chequamenon Bay
   - Marquette - Presque Isle

2. St. Marys River
   - Whitefish Bay to the Locks
   - Locks to Neebish Island
   - Neebish Island through Munuscong Lake
   - Munuscong Lake to Detour

3. Lake Michigan
   - Green Bay Harbor - Green Bay
   - Milwaukee
   - Calument
   - Indiana Harbor - Burns Harbor - Gary
   - Muskegon - Muskegon Lake
   - Ludington

4. Lake Huron
   - Alpena - Thunder Bay
   - Bay City - Saginaw Bay

5. St. Clair River
   - Blue Water Bridge to St. Clair
   - St. Clair to Marine City
   - Marine City to Algonac
   - Algonac to Lake St. Clair

6. Lake St. Clair

7. Detroit River
   - Head of Peach Island to Rouge River
   - Rouge River to Trenton
   - Trenton to Point Moullee

8. Lake Erie
   - West Basin
   - Monroe - Toledo
   - Sandusky - Sandusky Bay - Huron - Lorain
   - Cleveland
   - Ashtabula - Conneaut
   - Buffalo

9. Lake Ontario
   - Oswego
   - Cape Vincent

10. St. Lawrence River
    - Cape Vincent to Alexandria
    - Alexandria through Ogdensburg
    - Ogdensburg to Massena

5. IMPLEMENTATION

5.1 Program Management

5.1.1 Organization

The Environmental Studies for the Extended Season Program would be managed for the Corps of Engineers (COE) by the Great Lakes Region of the U.S. Fish and Wildlife Service (FWS). The terms and conditions for the management of these studies would be delineated in an agreement between the COE and the FWS. The present COE-FWS Interagency Agreement is presented in Attachment A.

5.1.2 Responsibilities and Authorities

The COE would have overall responsibility and authority for control of the Extended Season Program. The COE and the FWS would implement, coordinate, plan and continually refine the Environmental Plan of Action (EPOA).

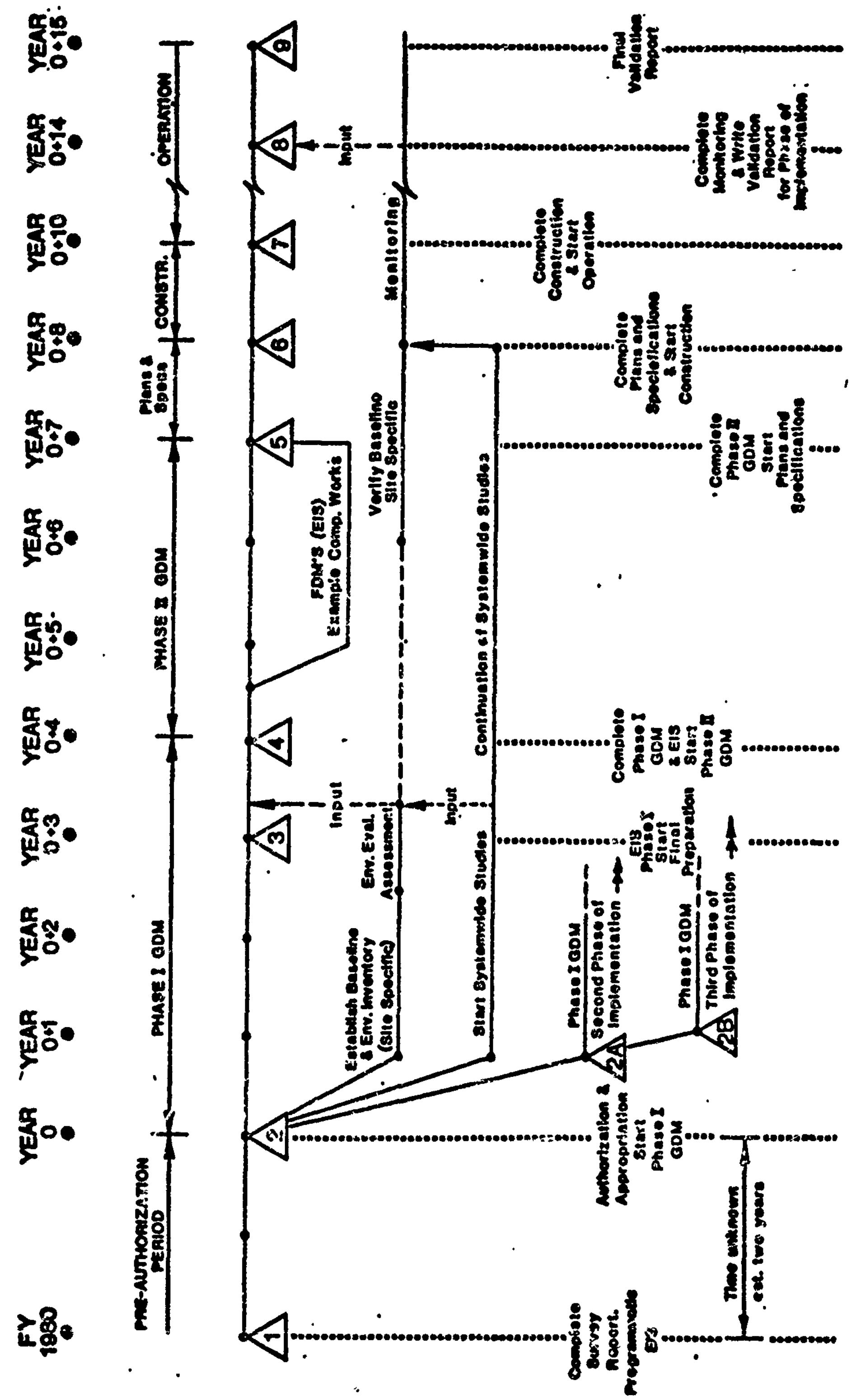
5.1.3 Public Involvement

In order to ensure full public participation and state involvement in the identification and designing of needed studies, an environmental assessment of the Great Lakes and St. Lawrence River ecosystem (EAGLE) team, would be established. This team would be involved in refinement of the EPOA. The states would be represented and meetings would be designed to encourage maximum public expression and involvement.

5.1.4 Extended Season Program Schedule

COE Adaptive Method. The EIS accompanying this Survey Report is programmatic in nature. It describes currently known environmental impacts that would result from the Extended Season Program. It also addresses potential, partially perceived, and unforeseen impacts on a regional scale and includes the proposed plan for determining which of these would actually occur (i.e., EPOA). The EIS, by means of this EPOA, presents the proposed program for assuring that the environment of the Great Lakes system would be considered adequately during development of an Extended Season Program. The proposed program also provides for the recommendation of means and measures for the elimination or minimization of adverse impacts which are necessary checks and balances to assure protection of the environment. For the level of detail available for this Survey Report, the Programmatic EIS is considered by the COE as an adequate procedure.

An understanding of the proposed plan can best be gained through reviewing the text below and referring to the diagram in Figure 1. That diagram outlines the plan, showing basic time frames, reports required, and inherent checks and balances.



ADAPTIVE METHOD DIAGRAM

FIGURE

Triangle 1 represents completion of this Survey Report which is scheduled for December 1979. Triangle 2 represents Congressional authorization and appropriation of funds, which could occur about 1982, should the Congress decide to authorize the proposed program. Since the actual time for authorization is unknown, the schedule on the diagram designates this point as year zero for scheduling subsequent activities and reports.

At year zero, following appropriations, the COE would begin detailed planning studies concurrently with obtaining base condition and inventory data. After a period of about 3-5 years, sufficient information would have been developed to allow for assessment including impact prediction and preparation of an EIS which would accompany the Phase I GDM to higher COE authority for approval. This EIS would be based on evaluation of the base condition data from both site-specific and system-wide studies. Using the FWS Assessment Methodology Technique, the evaluation report and the EIS would predict all impacts known at that time resulting from the program and would provide details on monitoring considered necessary to guard against unanticipated adverse impacts. On the diagram, the assessment and impact prediction would occur between Triangles 3 and 4.

Also, the key to understanding the COE Adaptive Method is the commitment that should the assessment indicate a need, the design of an item or planning activity could be modified during Phase I planning to mitigate, compensate or eliminate adverse impacts.

After approval of the Phase I GDM and EIS, the COE would begin Phase II studies which are detailed engineering design studies leading to preparation of plans and specifications. System-wide studies would continue during this period. At some point, about two years before construction is scheduled to begin (Triangle 6), the environmental base condition would be verified and updated and intensified, if warranted, in preparation for monitoring during construction and operation. Should the design be significantly altered or new information be developed showing a probability of a previously unanticipated impact, a new EIS would be prepared prior to construction. In addition, it is likely that for a major construction activity, such as compensating works, a Feature Design Memorandum (FDM) would be prepared. This FDM would describe only one item of construction and also would require the preparation of an EIS if the structure were altered significantly from previously described plans or if new potential impacts of the structure came to light since the previous EIS was completed.

During construction and operation (Triangles 7 through 8), environmental monitoring would be accomplished as a check on impact predictions and as a safeguard against unanticipated adverse impacts. The monitoring would compare the post-construction environmental conditions with preconstruction conditions. Should the monitoring indicate that a significant impact is occurring, any of several things would be done, depending on the nature of the impact. If the impact is found unacceptable, the cause would be eliminated, even to the halting of vessel traffic. If a lesser measure would accomplish a satisfactory result, it would be done. If an impact develops, which is considered acceptable but undesirable, appropriate measures would be taken to

mitigate, compensate or eliminate the impact; however, halting vessel transits would not be considered.

A Validation Report would be completed for each phase of implementation. A Final Validation Report would be written summarizing all preceding reports. These would be prepared after monitoring indicated that all impacts had been identified and evaluated and all recommendations for compensating, eliminating or mitigating impacts had been made and implemented. The Validation Reports would review the information obtained and recommend whether or not operation should continue. The Final Validation Report would provide the answer on the environmental acceptability of the Extended Season Program or any phase of the program.

Variations from Standard COE Procedure. The Adaptive Method process differs from standard COE procedures in four areas:

1. The EIS is programmatic in nature, addressing the impacts of the entire program on a level of detail less precise than, but supportive of, the engineering studies. The programmatic EIS addresses impacts on a regional scale and describes the program for predicting details of site-specific and system-wide impacts at appropriate times during the authorized preconstruction and pre-operational studies.

2. The Adaptive Environmental Assessment technique is employed to extend the customary assessment process, made in the planning phase, through construction and operation phases. The purpose of this technique should provide for better management responses to unanticipated adverse environmental impacts.

3. The Validation Report is a summary of evaluations and conclusions reached during the monitoring phase of the program. This is a new type of report, not previously accomplished in COE studies, and would be provided to the Congress. It would provide a vehicle for recommending that the program be either continued or halted, based on environmental acceptability. Reports for similar purposes have been previously prepared by the COE and distributed to other agencies but have not been sent to Congress.

4. The estimated cost of environment studies ranges from $100 to $150 million, and this appears higher than that expected for site-specific, water resource development projects. However, the environment study cost as a percentage of the total program cost is proportionate to the magnitude of the program. The factors which contribute to the cost are a lack of adequate information on the Great Lakes-St. Lawrence River winter ecosystems and other effects associated with navigation through ice.

COE-FWS Management Schedules. The COE Extended Season Program activities have been categorized into lake, harbor, and river systems to provide for detailed integration of engineering and environmental studies. An additional category was used for those engineering activities having system-wide impacts. The integration incorporates 71 area studies and 11 system-wide environmental studies with the engineering Extended Season Program activity. For clarity and ease of use, the categories were further broken down. As a result, the environmental studies were placed in phase with the engineering design studies for the major construction and operation activities proposed for each lake, harbor, or river system. These schedules have been computerized for use as a management tool to provide maximum flexibility for changes resulting from future refinements of the EPOA and are presented in Figures 2 through 12.

5.2 Data Management

Environmental data would be collected intermittently during a time span of 10 to 15 years. Many different organizations, including federal agencies, state agencies, universities, private research corporations, and consultants, would be needed to perform the large number of studies. These organizations would be geographically dispersed at least throughout the Great Lakes region. Also, the quantity of data to be generated would be very large; preliminary estimates of the number of observations are from 100 million to as much as 2 billion.

The quantity of data would require the use of computers to process and analyze the information. While most, if not all, the study participants will supply their own computers, these computers will encompass a large variety of manufacturers and sizes. However, a high degree of uniformity in data recording, handling and storage would be essential to ease the flow of information among the many organizations performing these studies as well as to assist the FWS in overseeing the studies and evaluating the results. The data generated in these studies would be the responsibility of the FWS. A comprehensive data management plan would be developed to assist the FWS in its management of the data and to describe the data management responsibilities of each of the participants.

The data management plan would describe the recommended formats for recording the various types of data, and, if a preferred method exists for gathering a specific type of data, the plan would specify the method. Criteria for selection of data to be placed in archives would be given in the plan and the preferred media for storing each type of data specified. The data management plan would include a description of the Great Lakes Information Management System (GLIMS), a FWS system for data storage, retrieval, and analysis.

The GLIMS, broadly defined, would consist of three major component subsystems:

1. Geo-based Information System (GIS). An Automatic Data Processing (ADP) subsystem that stores, accesses, retrieves, manipulates, and displays varied data keyed to spatial or geographic coordinates.

2. Textual and Bibliographic System (TBS). An ADP subsystem that stores, searches, and retrieves numeric, textual and bibliographic data. This subsystem will also archive the data generated in the FWS studies.

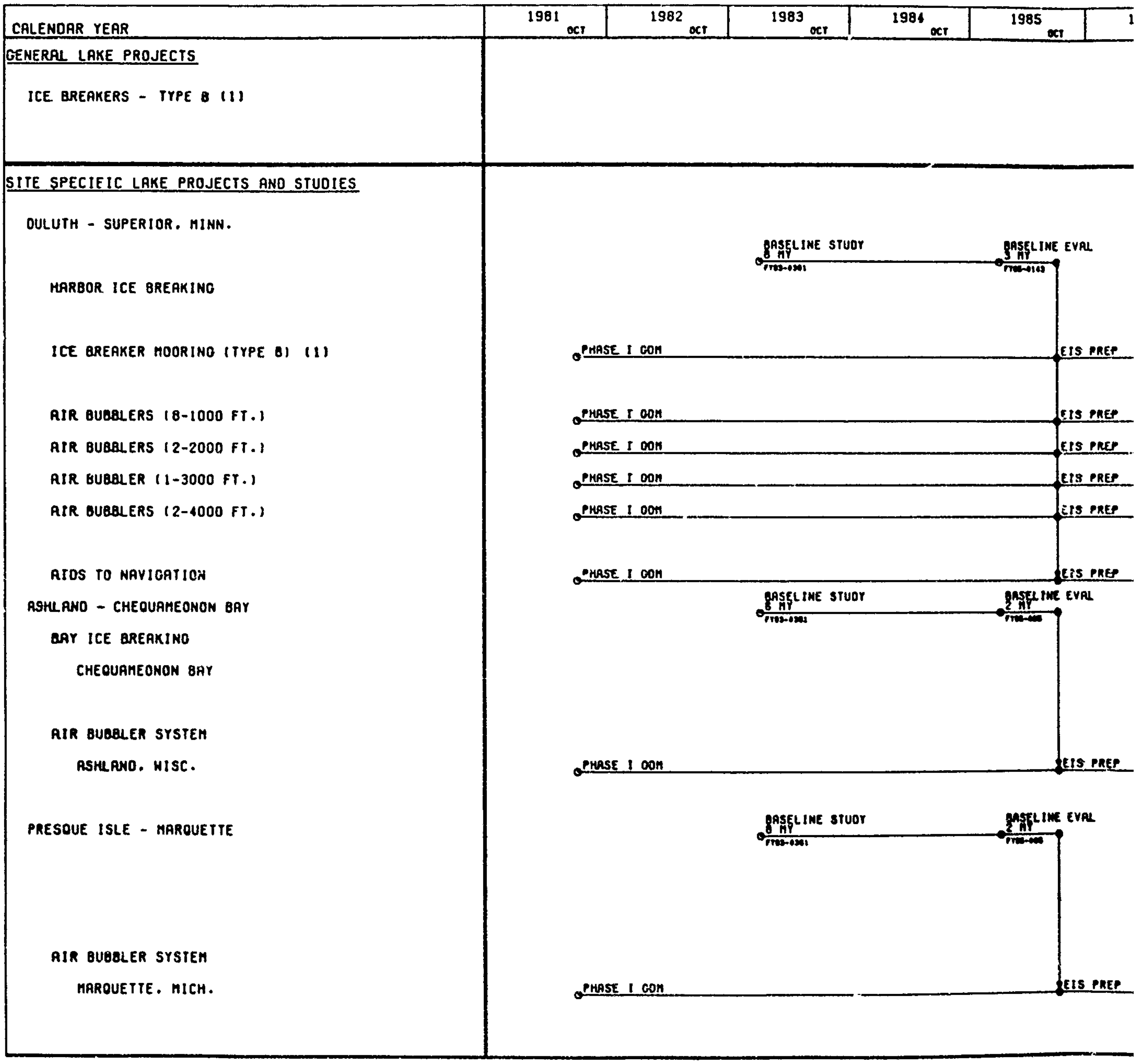
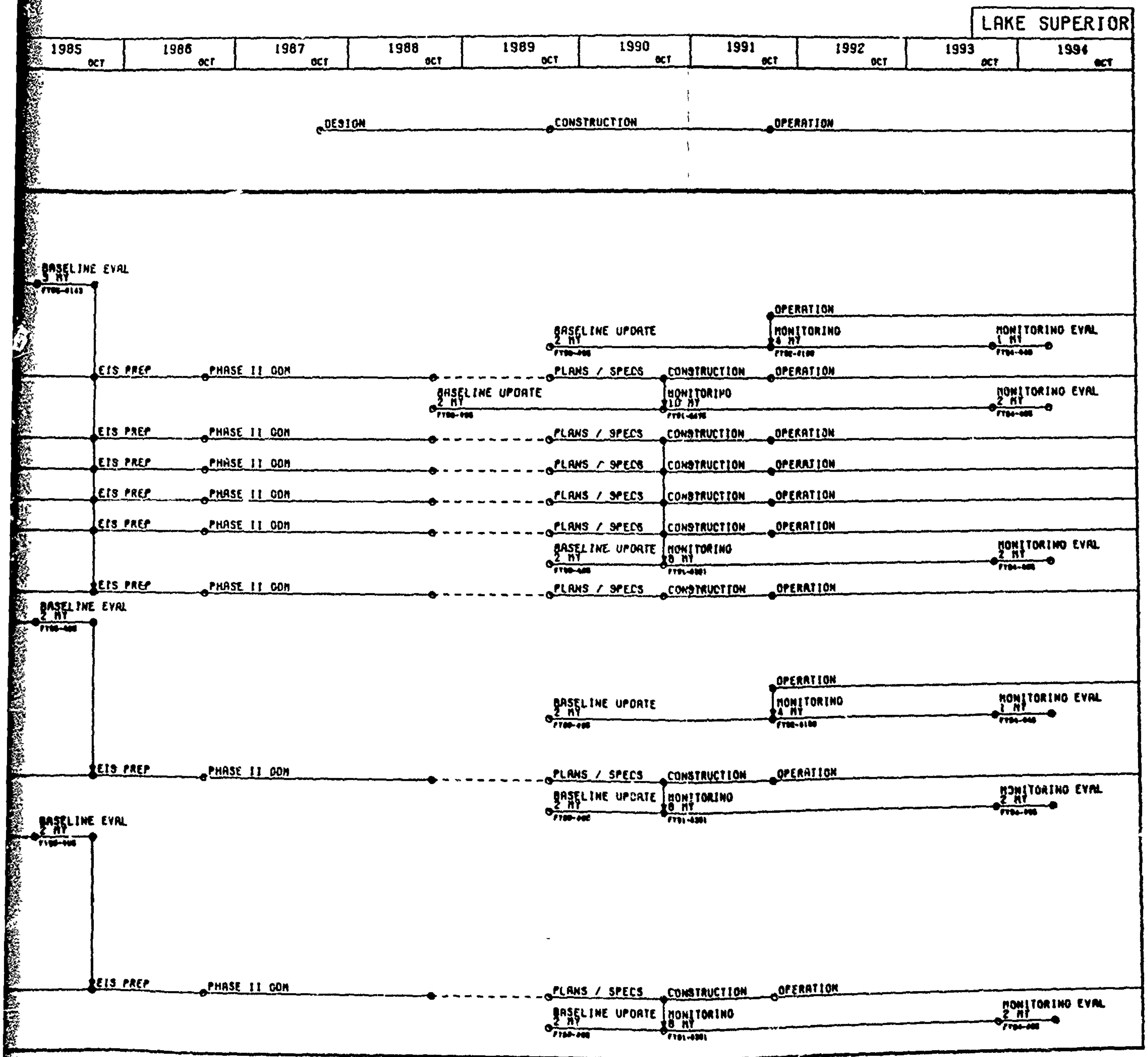


Figure 2. COE-FWS Management S

Figure 2



Management Schedule for Lake Superior

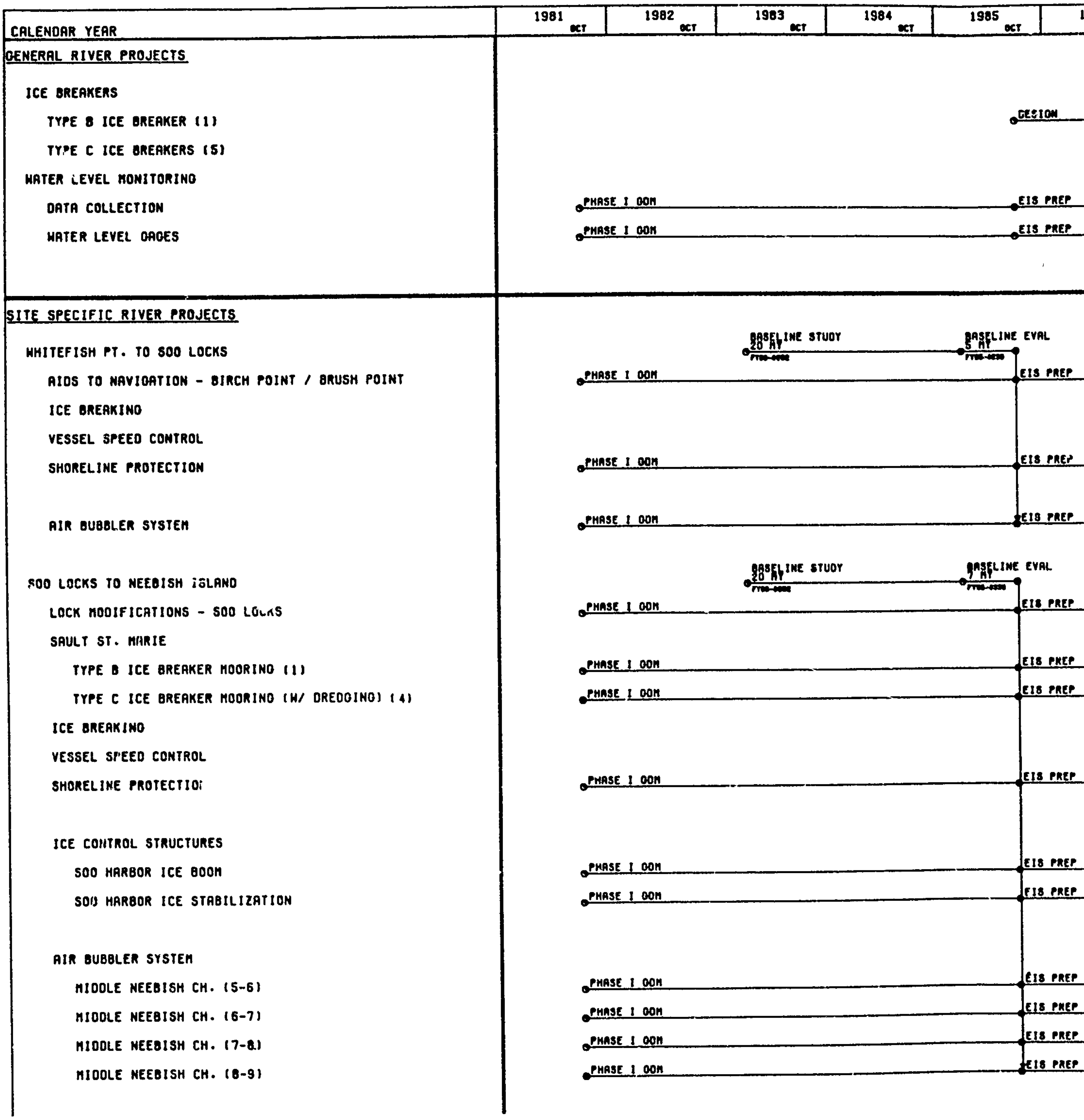
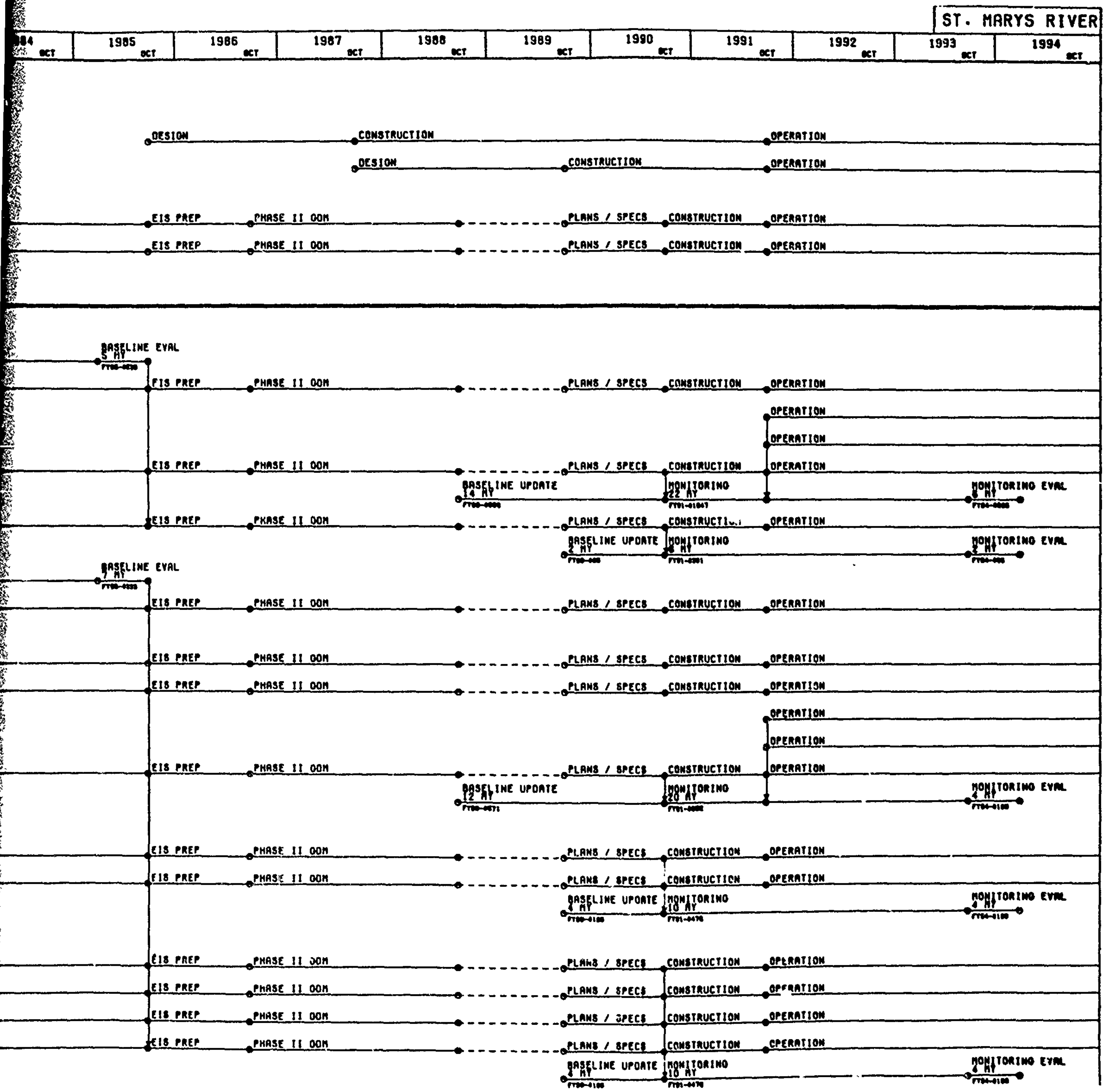


Figure 3. COE-FWS Management Sch

Figure 3



E-FWS Management Schedule for St. Marys River

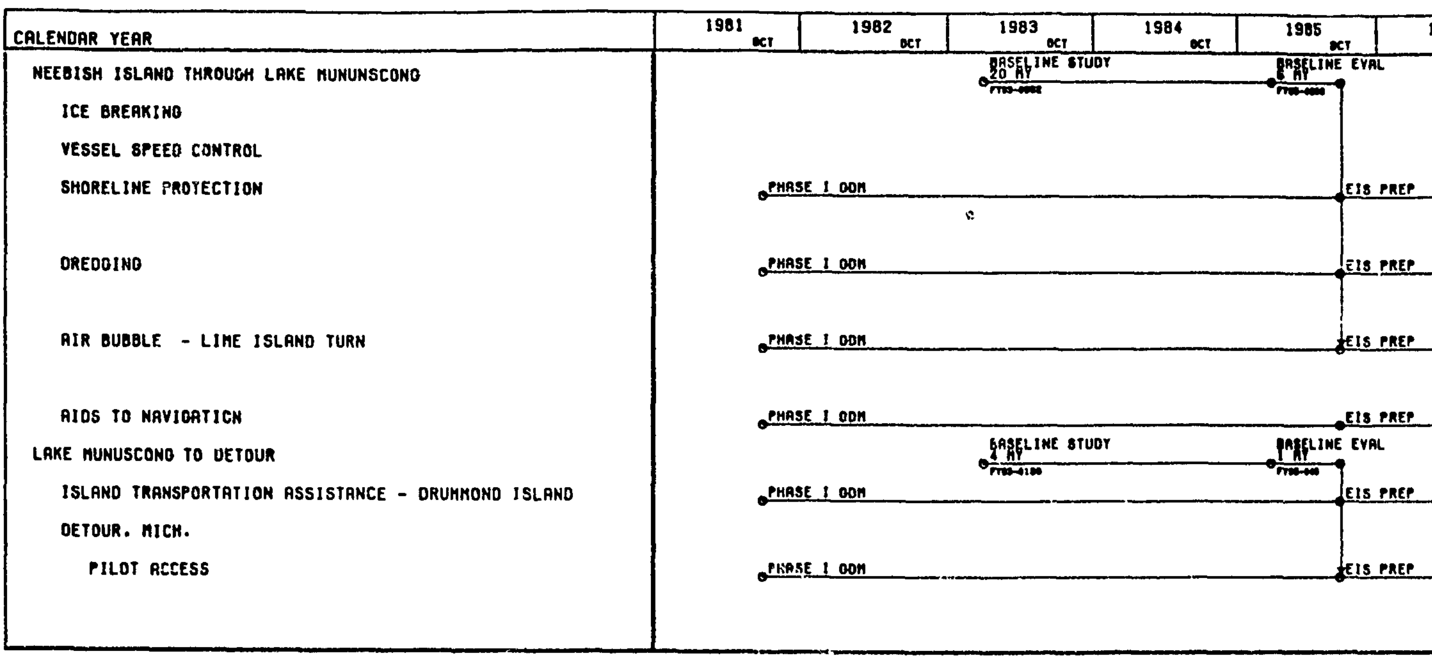
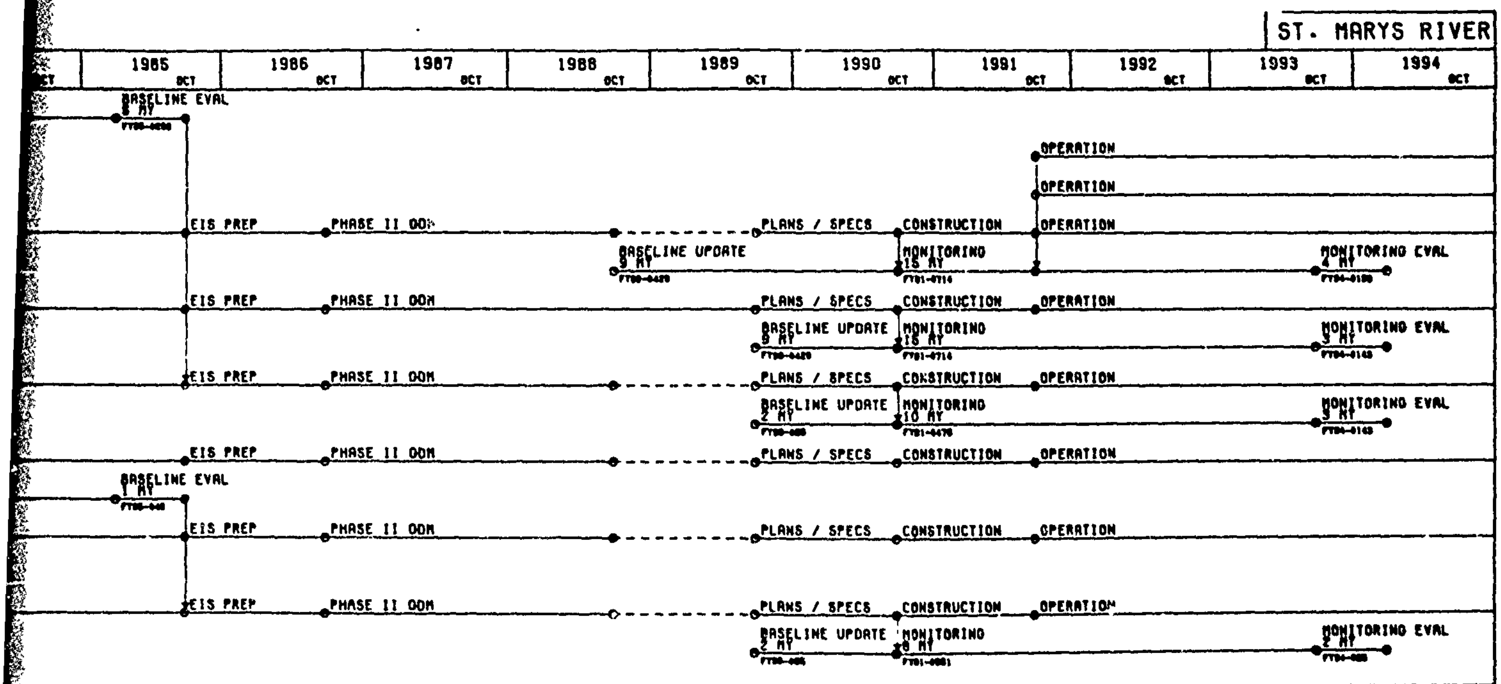


Figure 3. COE-FWS Management Schedule

Figure 3 (Cont.)



Management Schedule for St. Marys River (Continued)

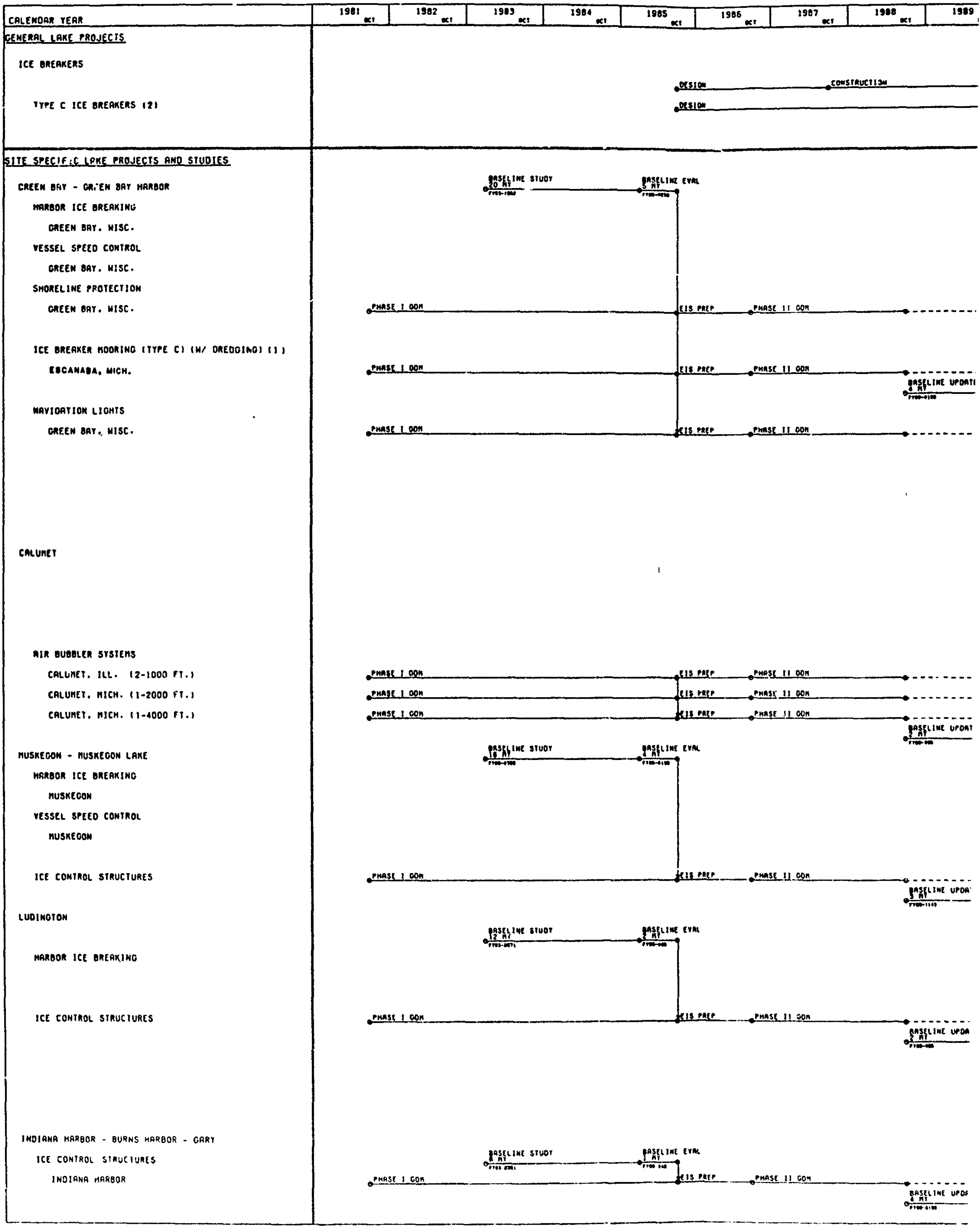
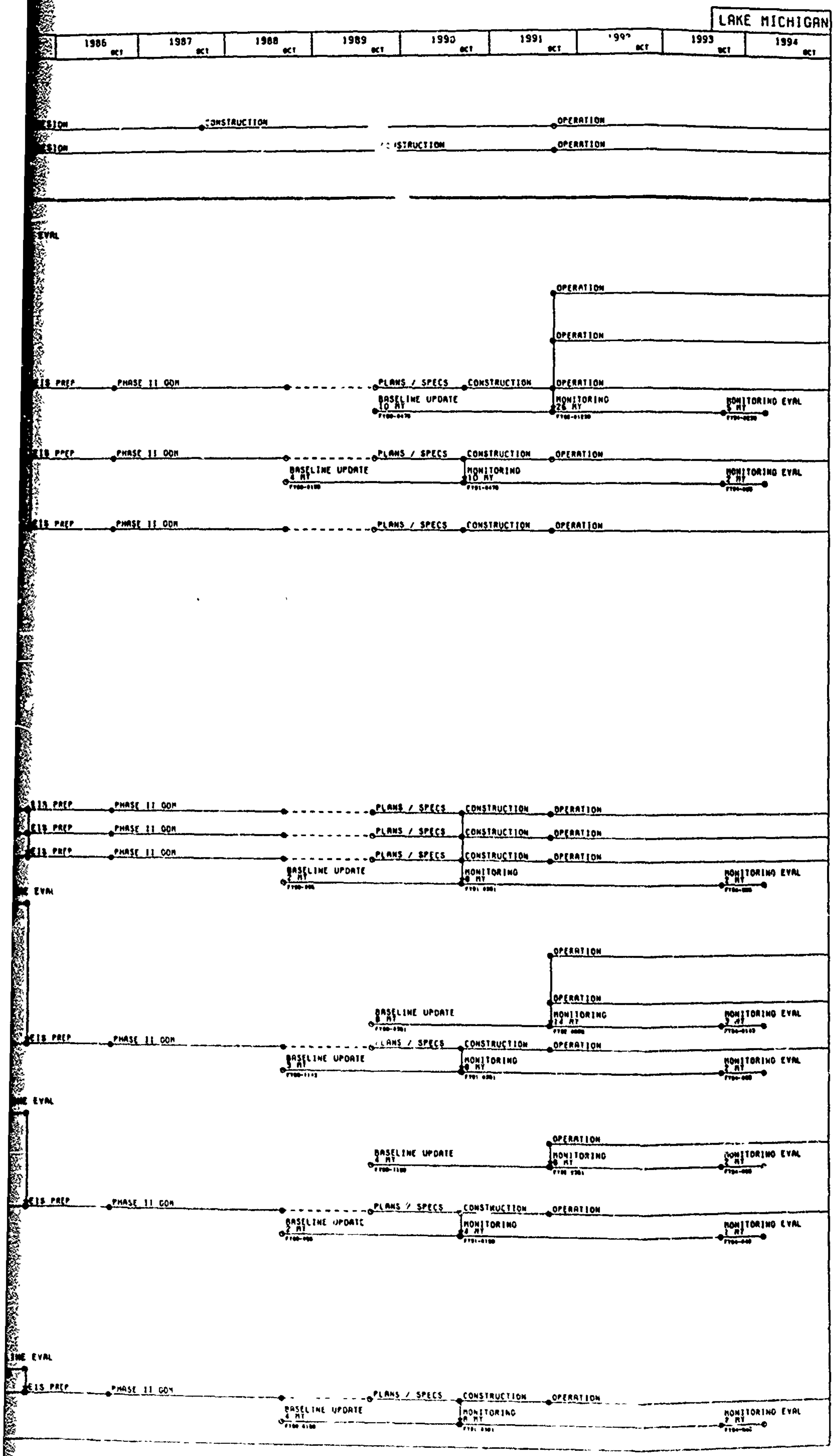


Figure 4. COE-FWS Management Schedule for Lake Michig

Figure 4



agement Schedule for Lake Michigan

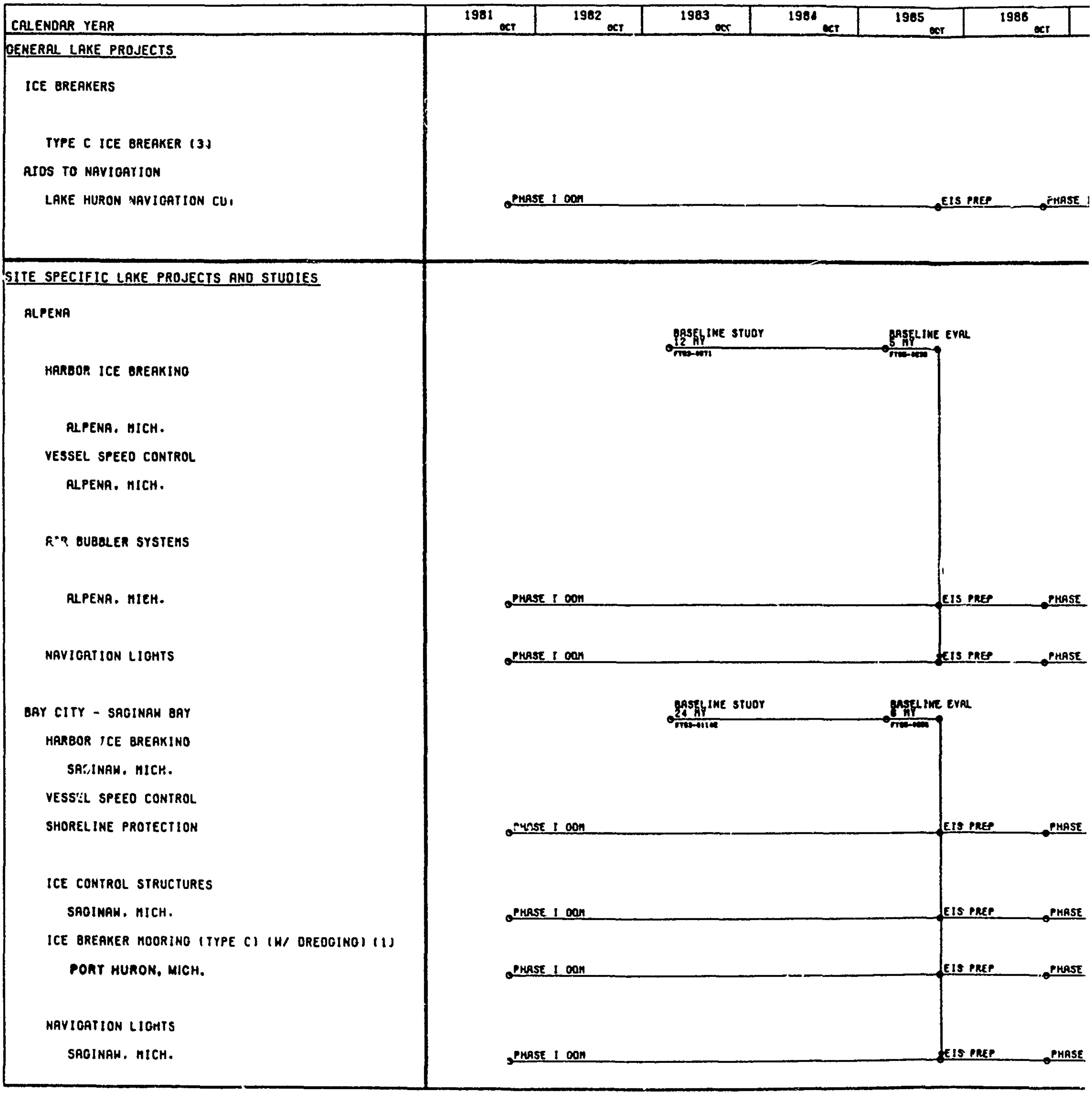
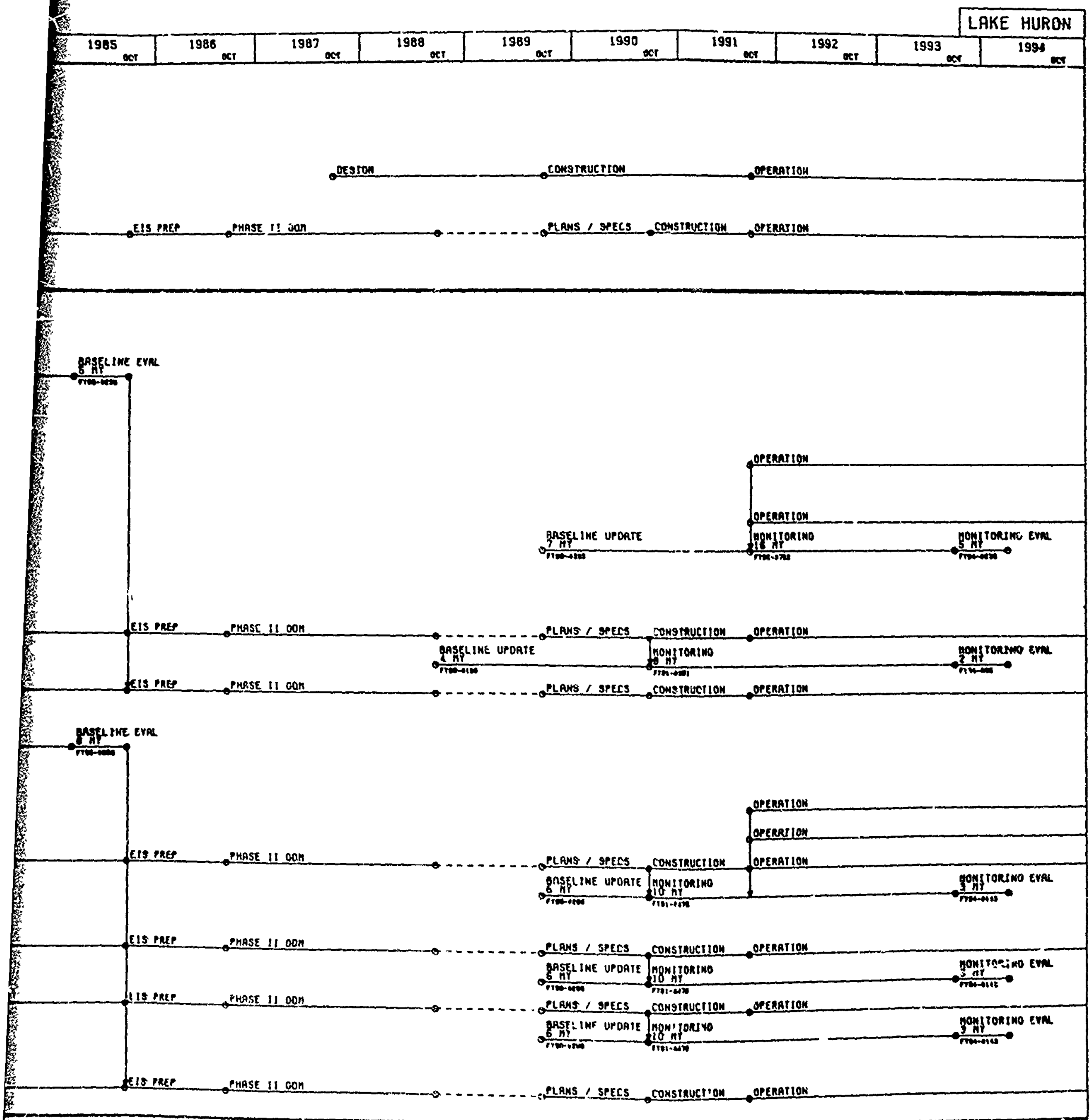


Figure 5. COE-FWS Managemer

Figure 5



5. COE-FWS Management Schedule for Lake Huron

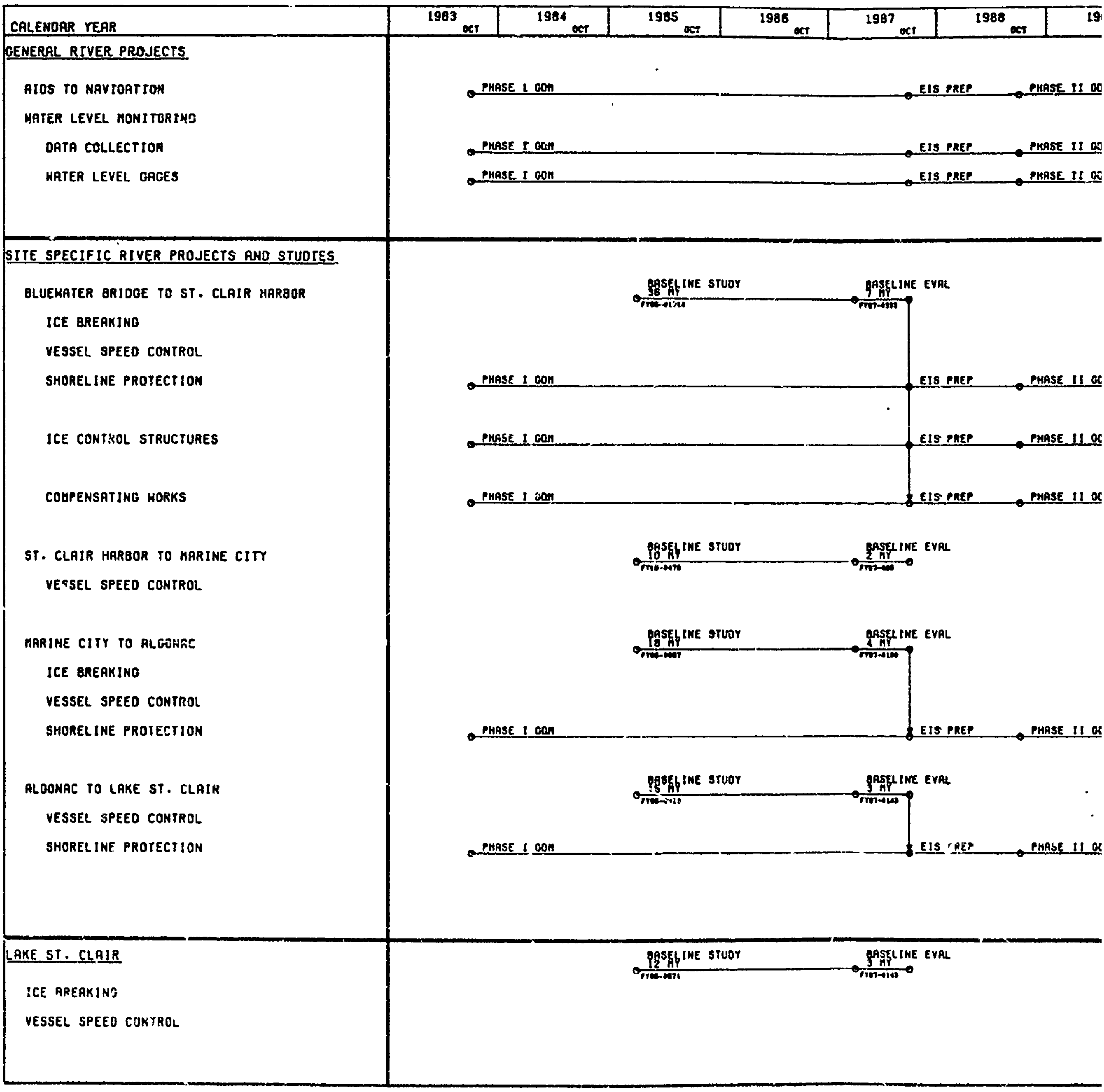
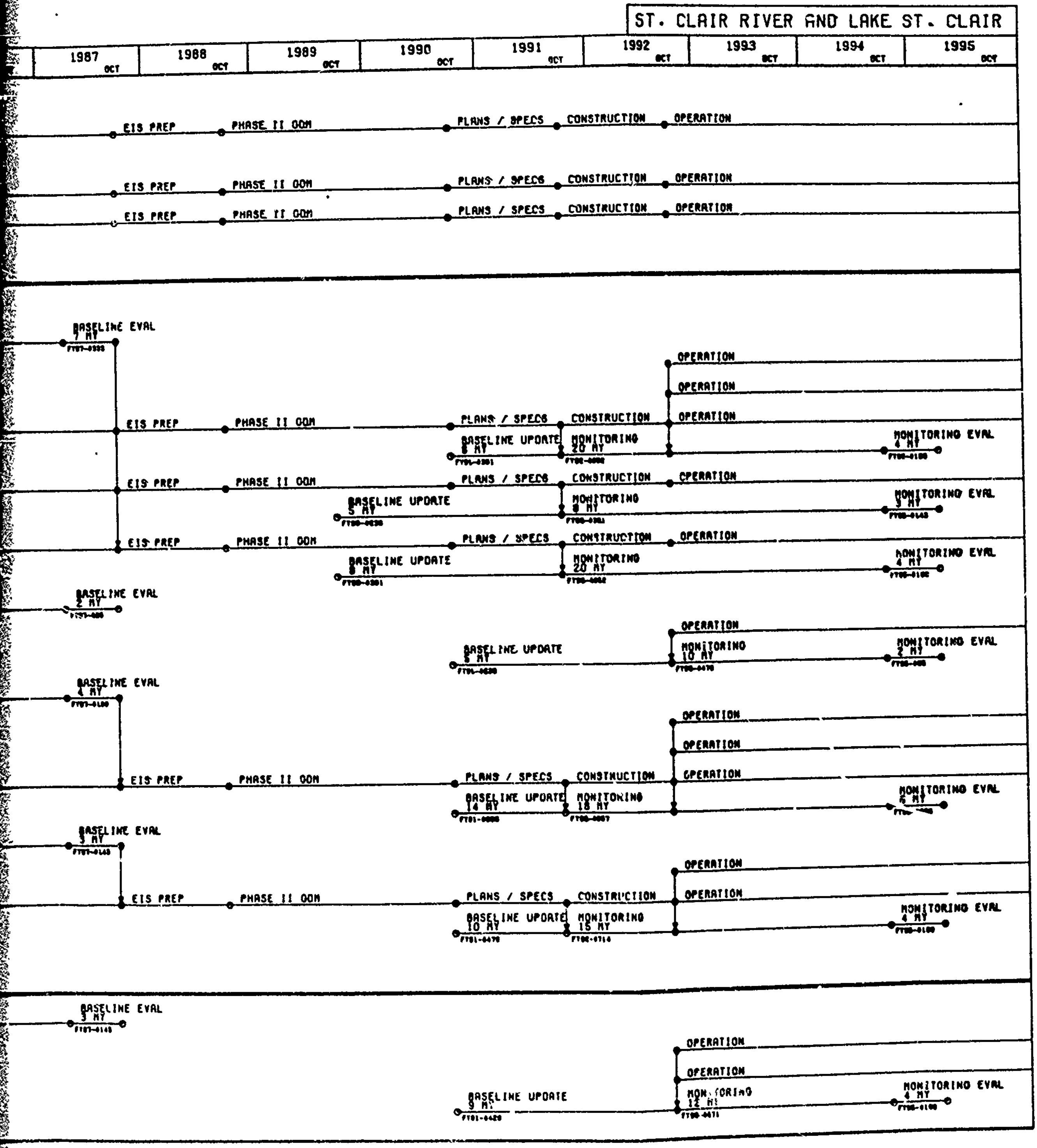


Figure 6. COE-FWS Management Schedule for St. Clair

Figure 6



...agement Schedule for St. Clair River and Lake St. Clair

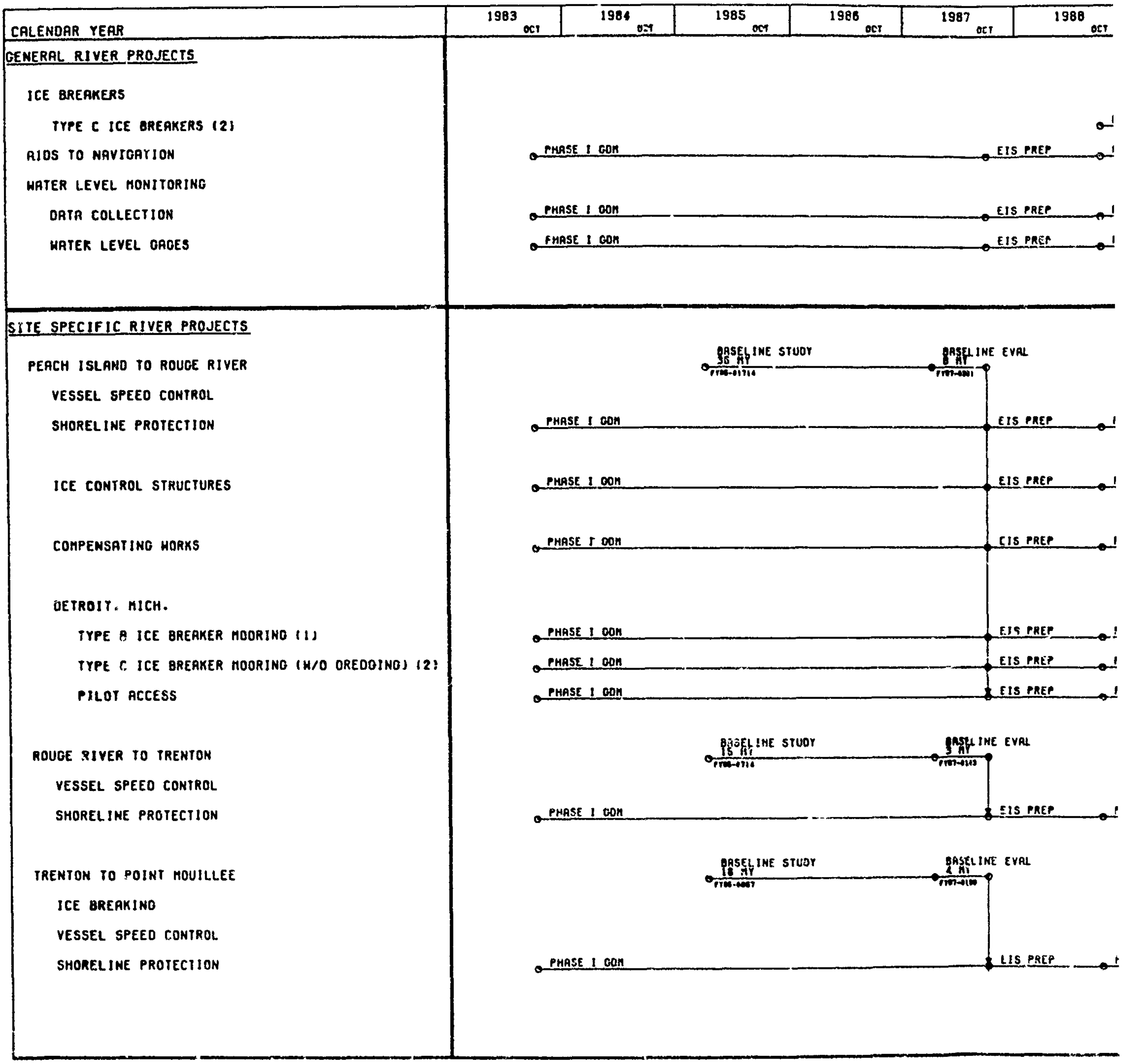
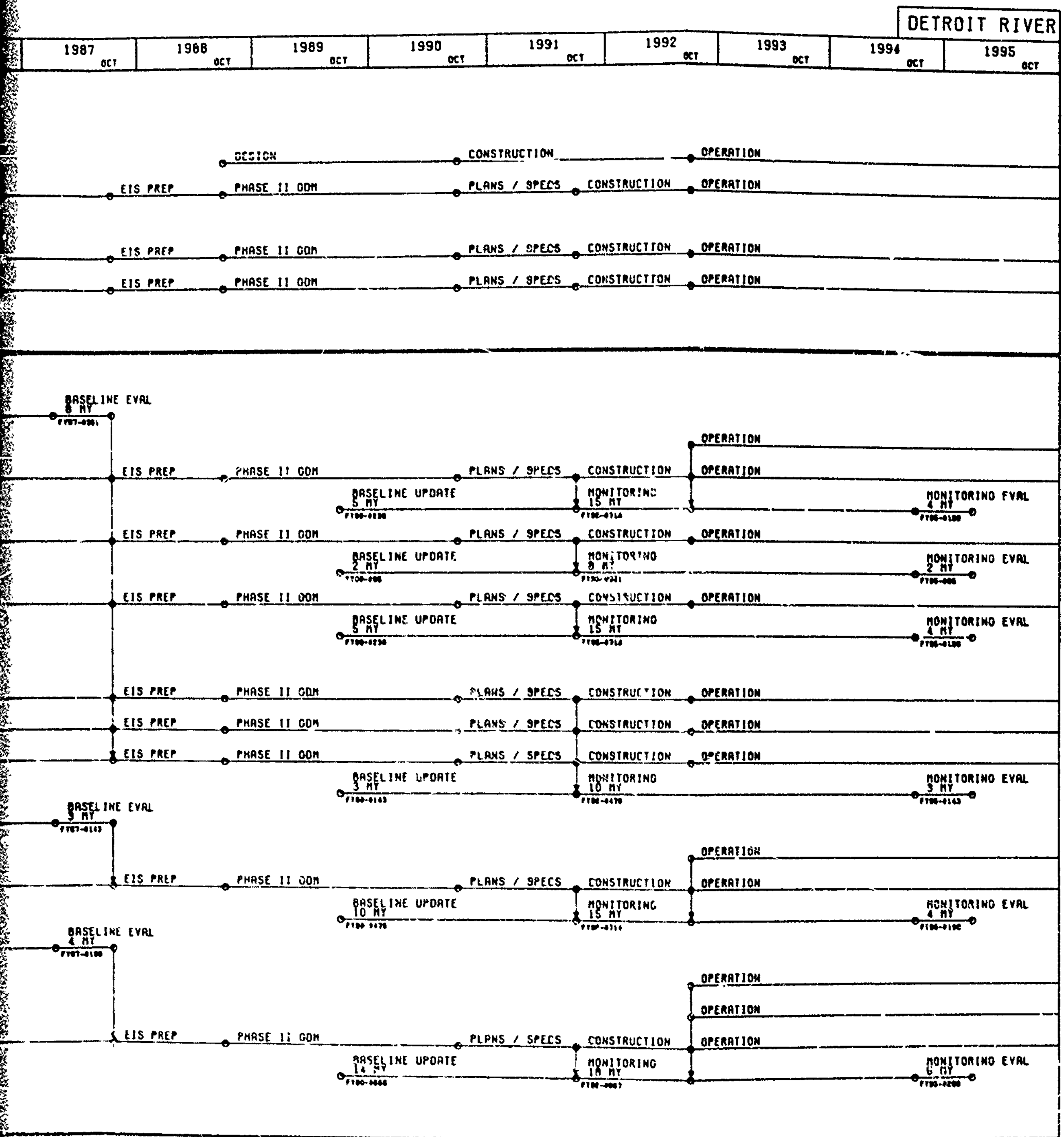


Figure 7. Coe-FWS Management Sched

Figure 7



FWS Management Schedule for Detroit River

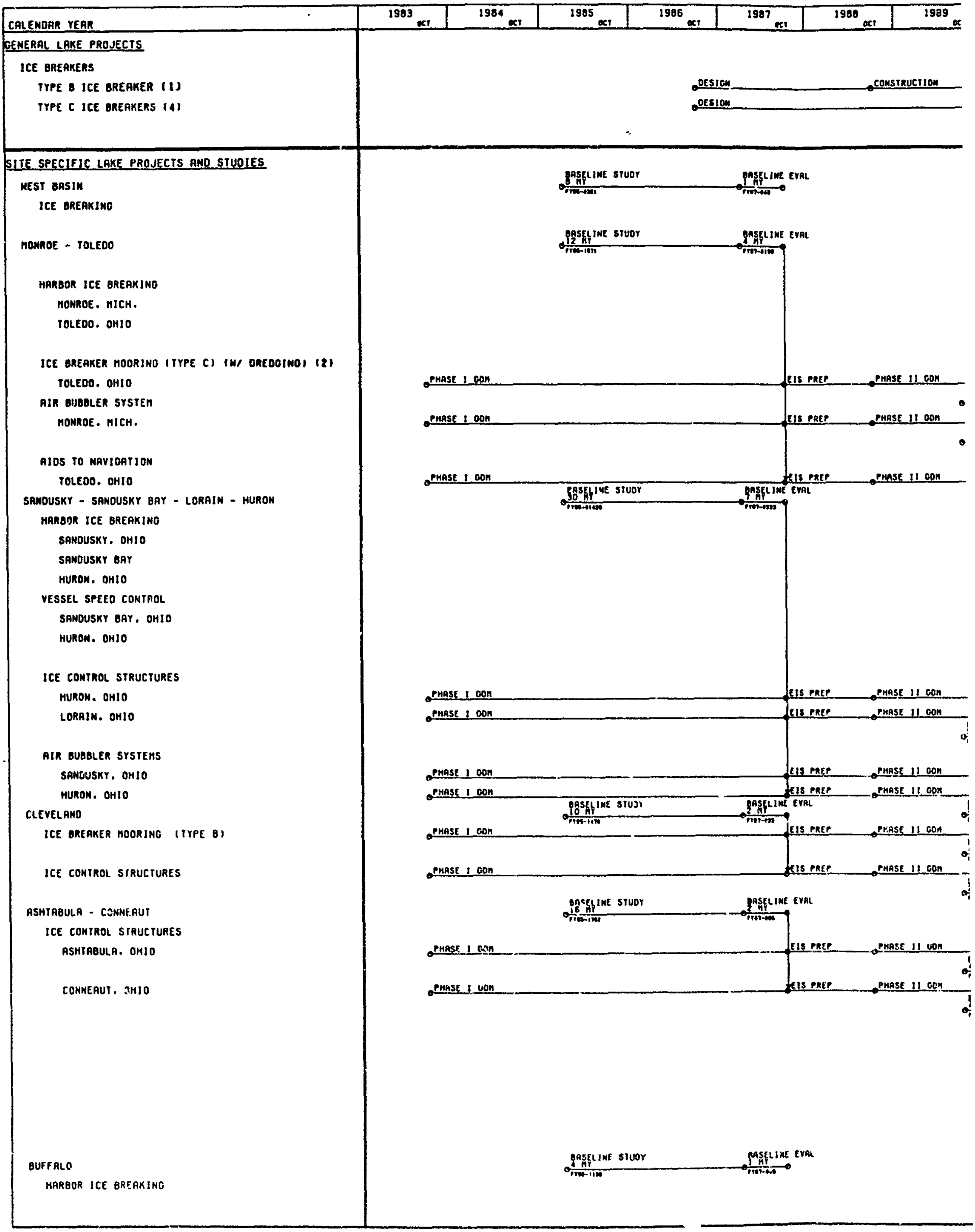
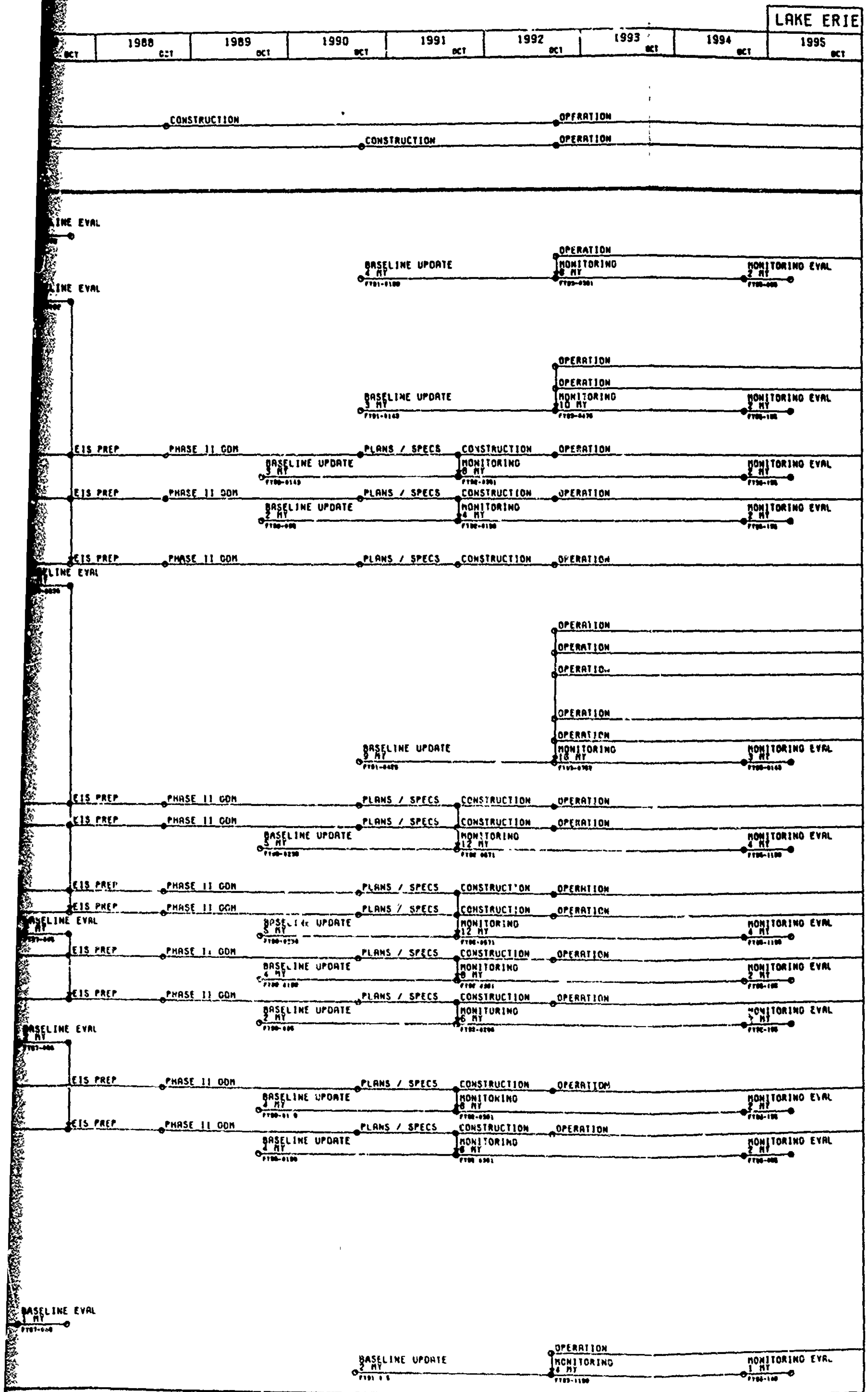


Figure 8. COE-FWS Management Schedule for L

Figure 8



Management Schedule for Lake Erie

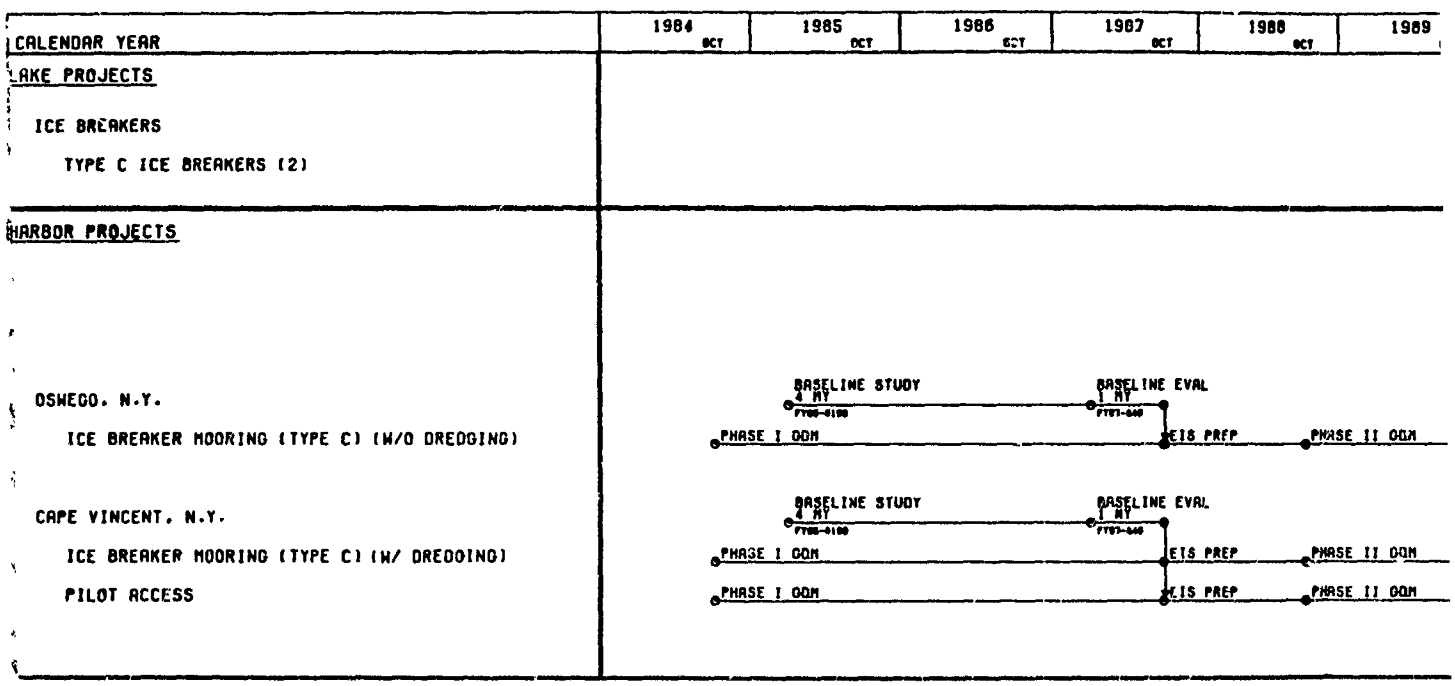
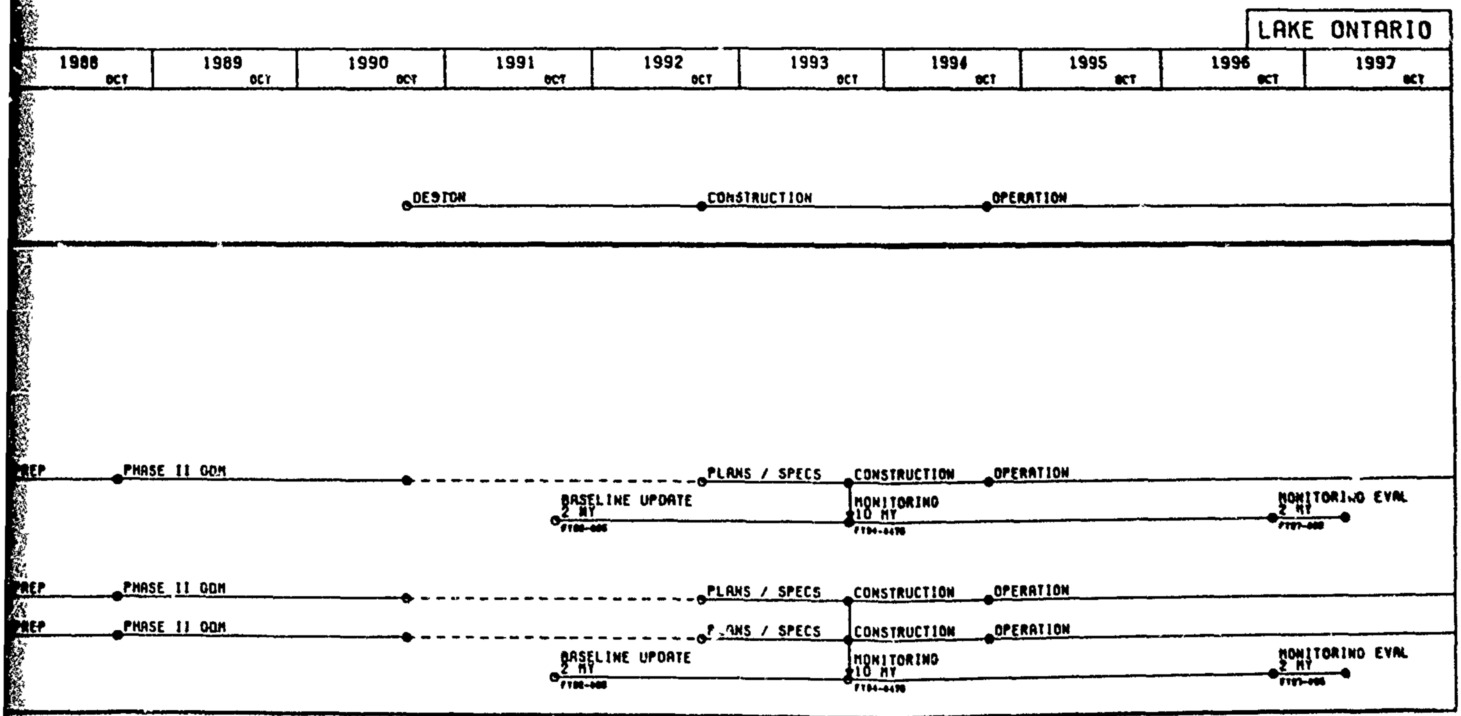


Figure 9. COE-FWS Management

Figure 9



-FWS Management Schedule for Lake Ontario

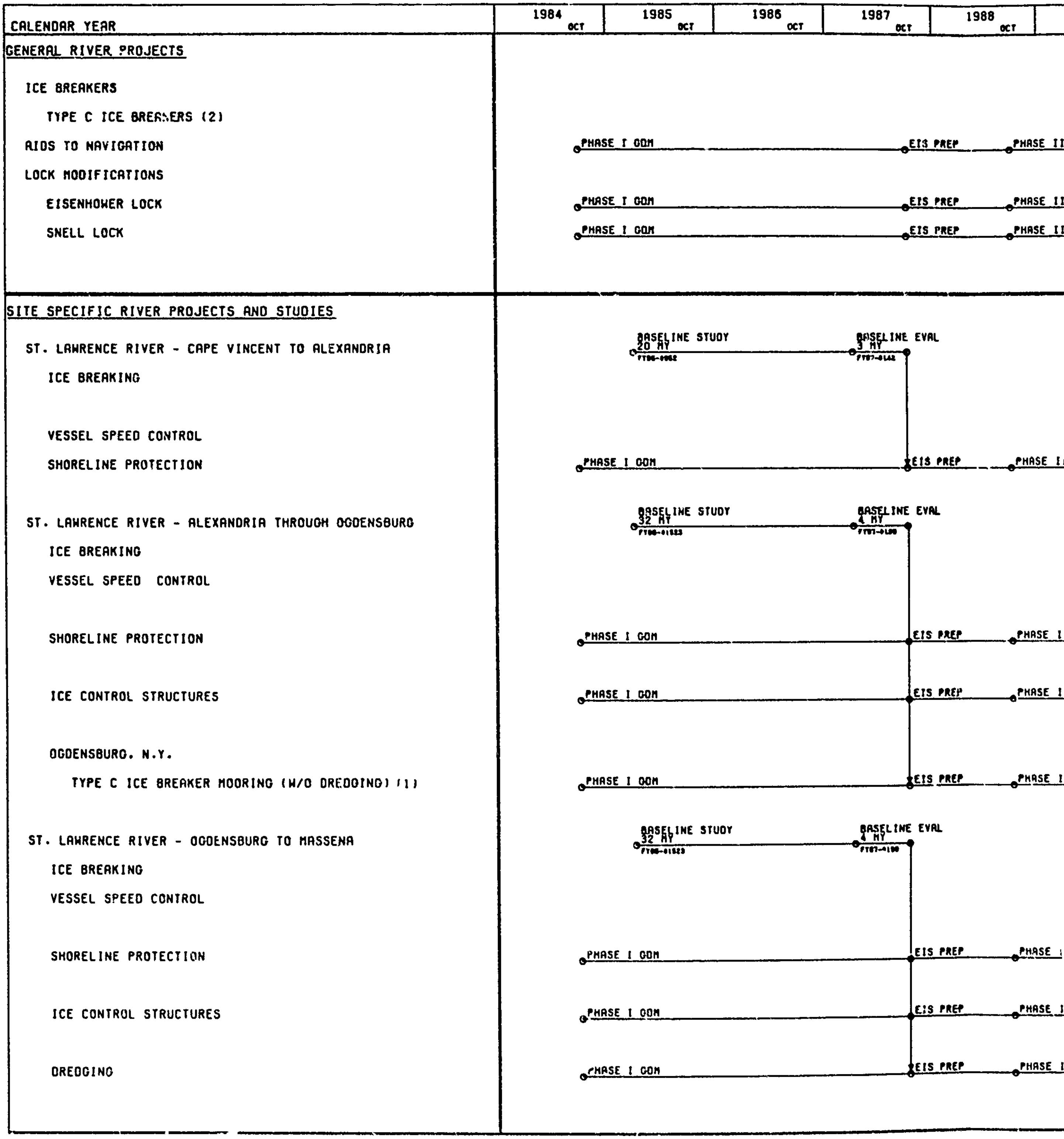
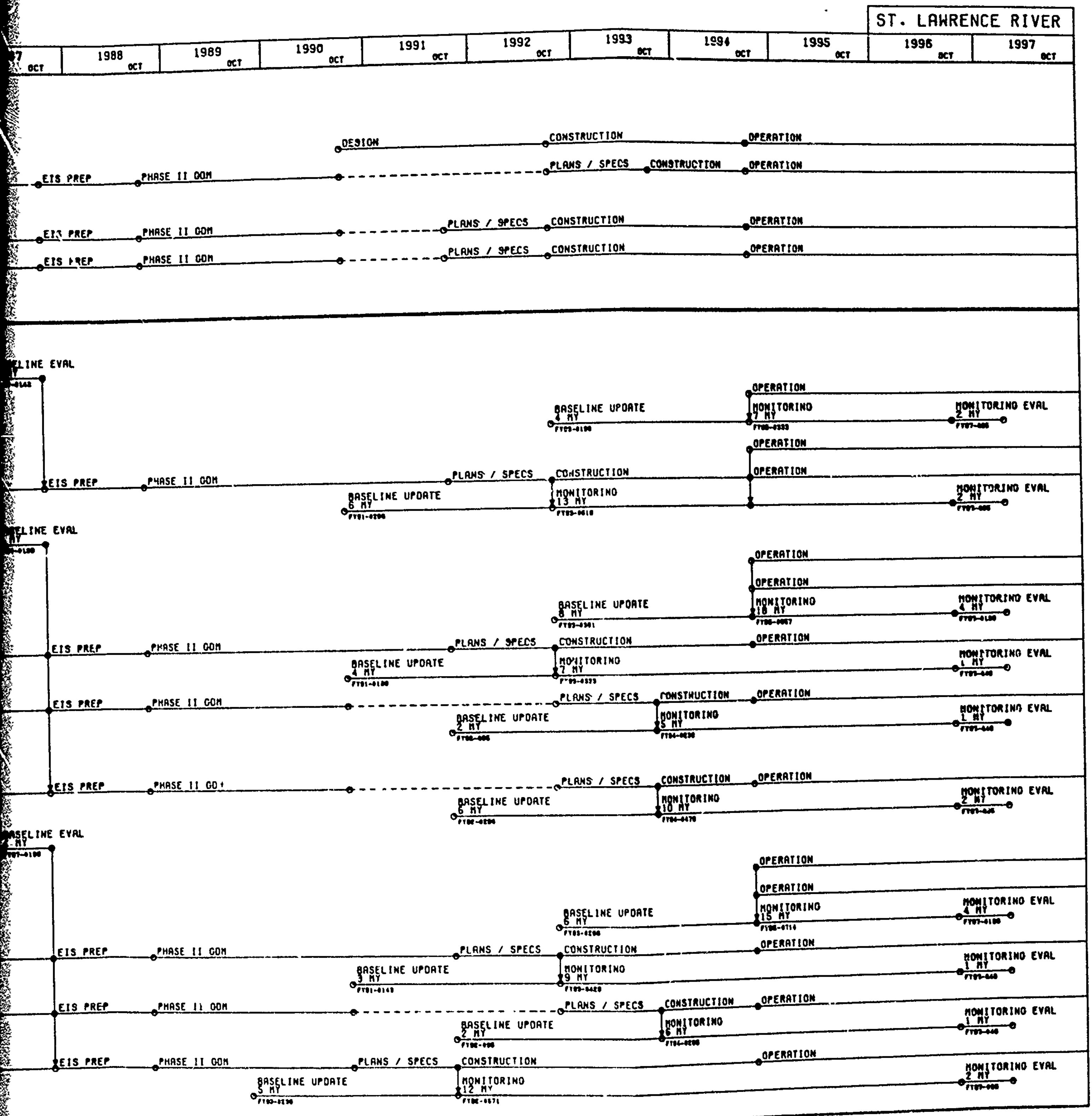


Figure 10. COE-FWS Management Sche

Figure 10



FWS Management Schedule for St. Lawrence River

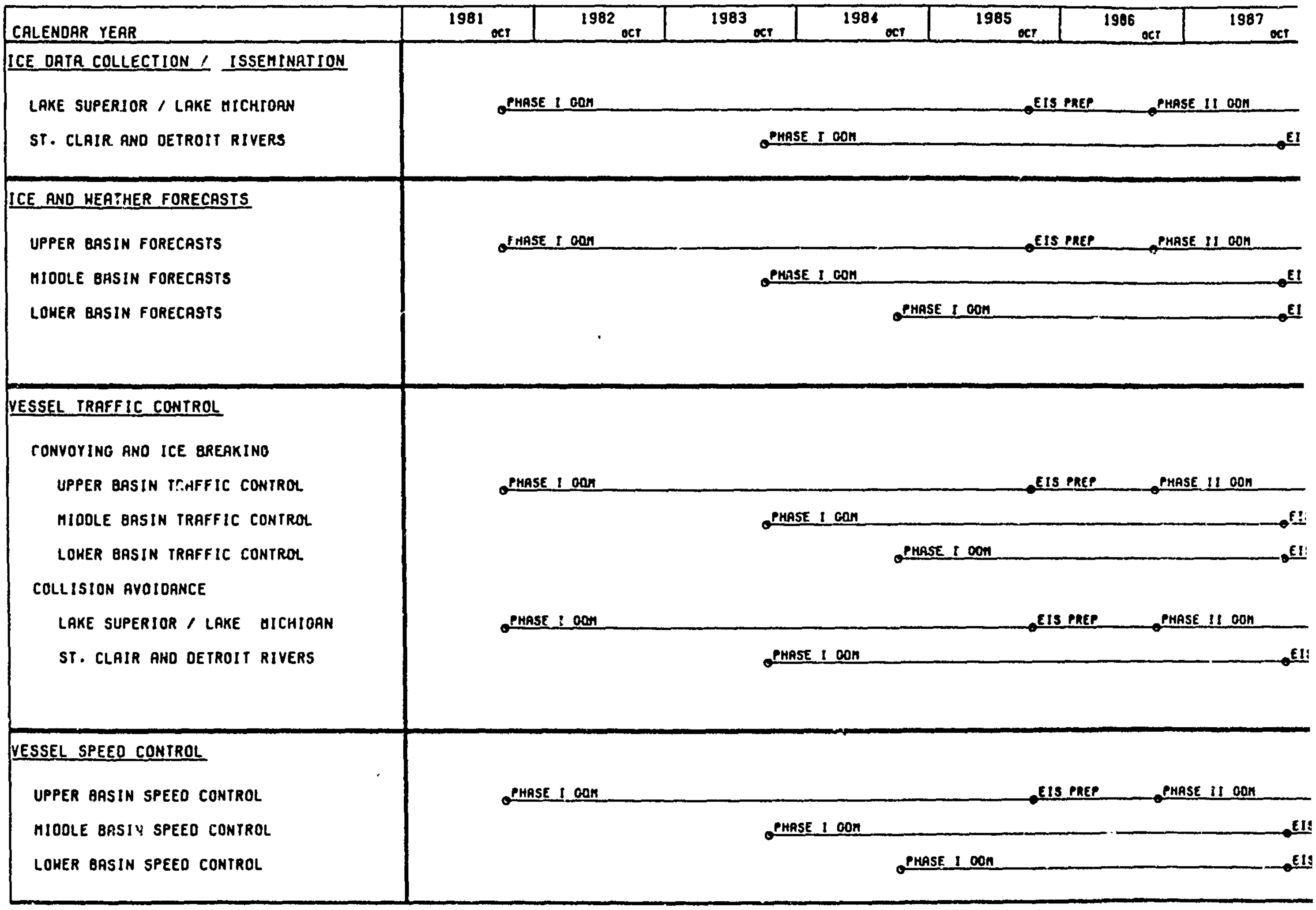
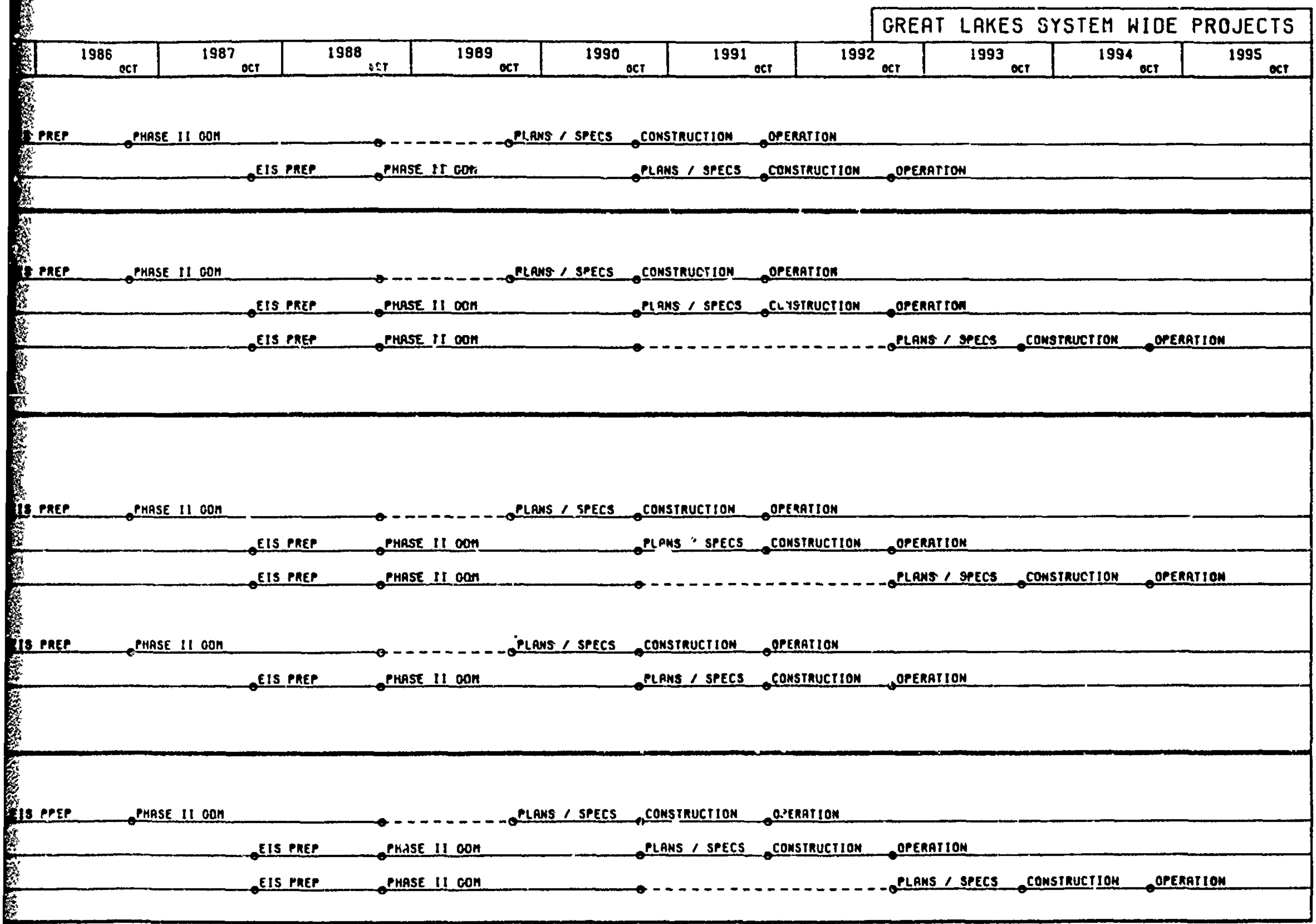


Figure 11. Great Lakes System-Wic

Figure 11



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Great Lakes System-Wide Projects

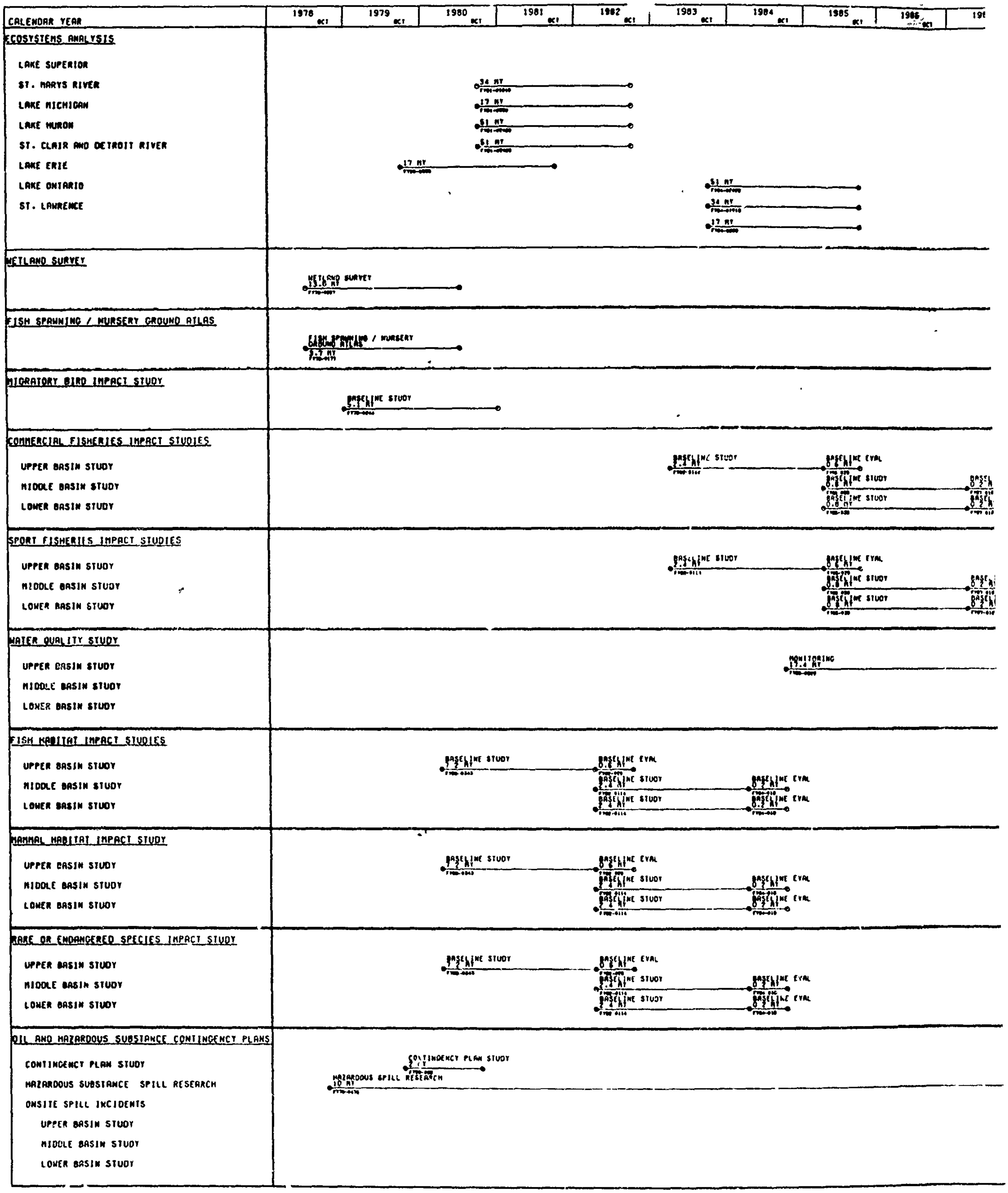
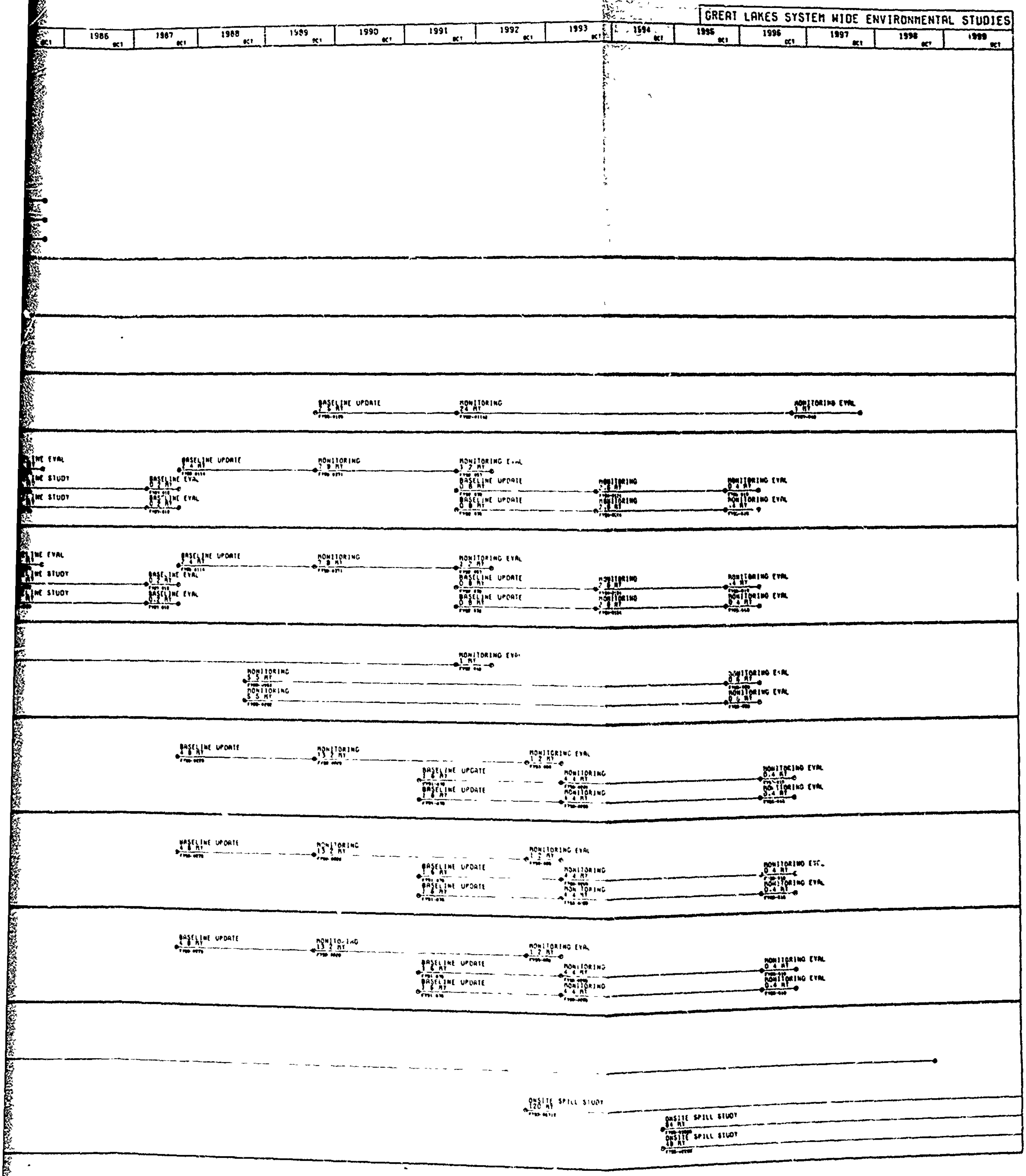


Figure 12. FWS Management Schedule fc

Figure 12



agement Schedule for Great Lakes System-Wide Studies

3. Numeric Information System (NIS). An ADP subsystem that relates primarily to mathematical models (e.g., simulations of ecological or environmental conditions). This subsystem utilizes the interrelations and changes of environmental variables to provide assessment and prediction indicators.

The GIS has been developed by the FWS Western Energy Land Use Team at Fort Collins, Colorado, and is operational on computers located in Fort Collins. GIS accepts a wide variety of input data formats, including maps, aerial photographs, and digital imagery. This includes data that have been and would be collected by the FWS and Corps of Engineers, as well as other data available in computerized and non-computerized files of other federal, state, local, and private entities. The non-digital data are digitized and stored in the GIS data base. The subsystem has the capability of performing geographic transformation of the data which allows the input data in various map projections, such as Tranverse Mercator or Albers Conformal, to be stored in one common projection and displayed in a user selected projection. GIS has the capability to retrieve data from its data base using location, individual element or descriptor criteria or any combination of these. The GIS output is primarily graphical displays or overlays. It also can provide simple statistical summaries and tabular reports.

Four implementation alternatives for the TBS have been examined. These alternatives are discussed in the report "Dedicated Environmental Data Base Feasibility Assessment," The Aerospace Corporation, September 1979. The four alternatives studied were: (1) contractor archives, (2) federal archive, (3) university archive, and (4) FWS archive. While each of these alternatives meet the basic requirements of the TBS subsystem, each alternative offers somewhat different capabilities to the Extended Season Program.

The contractor archives alternatives would probably be the lowest cost choice for the TBS subsystem, but it would provide the least security for the data and little, if any, capability for supporting other FWS computer system based tasks such as NIS. The federal archive alternative would provide the most secure data storage and require the least FWS management effort, but would provide no computer system support for other computer based tasks. Also, the projected costs would be greater than for the university archive alternative. The university archive alternative would provide considerable computer system support for other computer system based tasks, more data security than the contractor archives, and the projected cost would be less than for a federal archive. The FWS archive alternative would provide the most flexibility and the most rapid data access, but would be cost effective only if the new computer system required for TBS could also be utilized by other functions such as NIS and, perhaps, some non-Extended Season Program tasks.

Each of the TBS alternatives studied would include a computer based data catalog system which would contain a description of all the data obtained in the FWS Extended Season Program studies. This catalog system would be installed on a computer system which supports on-line, interactive local, and remote terminals which could be used to query the catalog system data base. Each of the study contractors would provide a concise input for the data catalog for each of the data files generated as part of this program. These inputs would contain a short

technical or scientific description of the data, the time and location of the data collected, the quantity of data, the form of data storage, and the name, address, and telephone number of the person to contact regarding the data.

The NIS is a collection of separate mathematical models for particular environmental or ecological conditions. Input data would come primarily from the FWS Extended Season Program studies, but pertinent data from other sources would be accepted. Results obtained from the NIS would contribute to the environmental predictions and evaluations.

GLIMS would be managed by the Biological Services Regional Team Leader of the Great Lakes Region of the U.S. Fish and Wildlife Services in support of the Corps of Engineers Extended Season Program. The archive selected by this manager would be the repository for the Extended Season Program original environmental data in the form of magnetic tape, photographs, maps, microfilm, microfiche, and hard copy reports. The Corps of Engineers would be a concurrent repository for duplicate copies of the completed reports and have access to the data base catalog.

5.3 Study Initiation Procedures

The implementation of the proposed studies, as provided for in a COE/FWS Interagency Agreement, would be accomplished: (1) inhouse, within the agency, through various research laboratories and groups; (2) through various other federal and state agencies utilizing Memorandums of Agreements; and (3) through academia, private corporations, groups, and entities using established federal contracting procedures.

6. COSTS

The proposed environmental studies, both area-specific and system-wide, have been estimated on the basis of required manyears of effort. The dollar equivalence for a single manyear of effort was assumed to be $47,600 for the entire program period. These estimates, of course, will have to be adjusted in the future to take into consideration cost increases due to inflation and other factors. However, at the present, they provide a point from which the overall cost of the environmental assessments may be evaluated on a constant dollar basis.

Tables 5, 6, 7, and 8 present the estimated funding needed for the basic environmental studies of the effects of the Extended Season Program on the natural environment. Tables 5 and 6 present cost breakdowns for the area-specific and system-wide studies respectively. Tables 7 and 8 present the annual allocation of funds required to coordinate these studies with the scheduled COE developments. The refinement process of the area-specific environmental stuides could result in study costs ranging from $100 to $150 million. The $127.6 million presently projected would provide over 2,740 manyears of effort throughout the Great Lakes-St. Lawrence basin. Studies included in this effort would be initiated upon authorization and appropriation for a projected period of 15 years. The Validation Reports and the study results would be provided to the COE for implemention of recommendations for the elimination of adverse environmental impacts. The results of the first evaluation process of the construction and operation phases would also be given to the COE so that any adverse effects identified may be eliminated or minimized.

Table 5.

Proposed Environmental Study Costs for Area-Specific Studies

Geographic Area	Environmental Study Costs ($1000)	
1. Lake Superior		
Duluth - Superior	2094	
Ashland - Chequamenon Bay	1380	
Marquette - Presque Isle	1713	
Total		5187
2. St. Marys River		
Whitefish Bay to the Locks	3760	
Locks to Neebish Island	4710	
Neebish Island through Munuscong Lake	4569	
Munuscong Lake to Detour	809	
Total		13848
3. Lake Michigan		
Green Bay harbor - Green Bay - Escanaba	3903	
Milwaukee	904	
Calumet	1713	
Indiana Harbor - Burns Harbor - Gary	1095	
Muskegon - Muskegon Lake	2761	
Ludington	1665	
Total		12041
4. Lake Huron		
Alpena - Thunder Bay	808	
Bay City - Saginaw Bay	4143	
Total		6951
5. St. Clair River		
Blue Water Bridge to St. Clair	5855	
St. Clair to Marine City	1380	
Marine City to Algonac	2856	
Algonac to Lake St. Clair	2237	
Total		12328
6. Lake St. Clair		1904
7. Detroit River		
Head to Peach Island to Rouge River	5712	
Rouge River to Trenton	2237	
Trenton to Point Mouilee	2856	
Total		10805
8. Lake Erie		
West Basin	1095	
Monroe - Toledo	2474	
Sandusky - Sandusky Bay - Huron - Lorain	5093	
Cleveland	1713	
Ashtabula - Conneaut	2189	
Buffalo	571	
Total		13135
9. Lake Ontario		
Oswego	904	
Cape Vincent	904	
Total		1808
10. St. Lawrence River		
Cape Vincent to Alexandria	2712	
Alexandria through Ogdensburg	4950	
Ogdensburg to Massena	4856	
Total		12518

Table 6.

Proposed Environmental Study Costs for System-Wide Studies

Type of Study	Costs ($1000)			
	Baseline	Baseline Update	Monitoring	Total
Ecosystems Analysis				
Lake Superior				1618
St. Marys River				804
Lake Michigan				2428
Lake Huron				2428
St. Clair & Detroit River				809*
Lake Erie				2428
Lake Ontario				1618
St. Lawrence				809
Total				12,947
Wetland Survey				657*
Fish Spawning/Nursery Growth Atlas				177*
Migratory Bird Impact	244*	125	1190	1559
Commercial Fisheries Impact				
Upper Basin	143	114	428	685
Middle Basin	48	38	143	229
Lower Basin	48	38	143	229
Total	239	190	714	1143
Sport Fisheries Impact				
Upper Basin	143	114	4281	685
Middle Basin	48	38	143	229
Lower Basin	48	38	143	229
Total	239	190	714	1143
Water Quality			876	876
Upper Basin			290	290
Middle Basin			290	290
Lower Basin			290	290
Total			1456	1456
Fish Habitat Impact				
Upper Basin	371	229	686	1286
Middle Basin	124	76	228	428
Lower Basin	124	76	228	428
Total	619	381	1142	2142
Mammal Habitat Impact				
Upper Basin	371	229	686	1286
Middle Basin	124	76	228	428
Lower Basin	124	76	228	428
Total	619	381	1142	2142
Rare or Endangered Species Impact				
Upper Basin	371	229	686	1286
Middle Basin	124	76	228	428
Lower Basin	124	76	228	428
Total	619	381	1142	2142
Oil and Hazardous Substance Contingency Plans				
Contingency Plan Study				95
Hazardous Substance Spill Research				476
On Site Spill Incidents				
Upper Basin				5712
Middle Basin				3998
Lower Basin				2285
Total				12,566
GRAND TOTAL				38,074**

* Studies started and funds committed.

**$1887 of this amount already funded.

Table 7.

Annual Environmental Study Costs for Area-Specific Studies

FISCAL YEAR DISTRIBUTION OF ENVIRONMENTAL COSTS ($1000)

	1983	84	85	86	87	88	89	90	91	92	93	94	TOTAL
Lake Superior													
Duluth-Superior	381		143				95	190	857	190		238	2094
Ashland-Chequamenon Bay	381		95					190	381	190		143	1380
Marquette-Presque Isle	381		95					190	857			190	1713
St. Marys River													
Whitefish Point to Locks	952		238				666	95	1428			381	3760
Locks to Neebish Island	952		333				571	380	1904			570	4710
Neebish Island through Lake Munuscong	952		286				428	523	1904			476	4569
Lake Munuscong to Detour	190		48					95	381			95	809
Lake Michigan													
Green Bay, Green Bay Harbor, Escanaba	952		283					666		1714		333	3903
Milwaukee	190		48					95	476			95	904
Calumet	381		95					95	381			95	1047
Indiana, Burns, Gary	381		48					190	381			94	1094
Muskegon-Muskegon Lake	762		190					524	1047			238	2761
Ludington	571		95					285	190	381		143	1665
Lake Huron													
Alpena	571		238					523		1143		333	2808
Bay City, Saginaw Bay	1142		286					858	1428			429	4143

Table 7. (Continued)

Annual Environmental Study Costs for Area-Specific Studies

FISCAL YEAR DISTRIBUTION OF ENVIRONMENTAL COSTS ($1000)

	1985	86	87	88	89	90	91	92	93	94	95	96	97	TOTAL
St. Clair River														
Bluewater Bridge to St. Clair Harbor	1714		333			619	381	2285			523			5855
St. Clair Harbor to Marine City	476		95				238		476		95			1380
Marine City to Algonac	857		190				666	857			286			2856
Algonac to Lake St. Clair	714		143				476	714			190			2237
Lake St. Clair	571		143				429		571		190			1904
Detroit River														
Peach Island to Rouge River	1714		381			714		2285			618			5712
Rouge River to Trenton	714		143			476		714			190			2237
Trenton to Pt. Mouillee	857		190			666		857			286			2856
Lake Erie														
Lake Erie (West Basin)	381		48				190		381		95			1095
Monroe, Toledo Harbors	571		190			238	143	571	476		285			2474
Sandusky Bay, Sandusky, Huron, Lorain	1428		333			476	429	1142	762		523			5093
Cleveland	476		95			285		667			190			1713
Astabula, Conneaut	762		95			380		762			190			2189
Buffalo	190		48			286	95	476	190		143			1428
Lake Ontario														
Oswego	190		48					95		476			95	904
Cape Vincent	190		48					95		476			95	904
St. Lawrence River														
Cape Vincent to Alexandria	952		143			286	286	476	809		333		285	3570
Alexandria to Ogdensburg	1523		190				190	381	714	714	857		381	4950
Ogensburg to Massena	1523		190			233	143	666	715	286	714		381	4856

Table 8.

Annual Environmental Study Costs for System-Wide Studies

FISCAL YEAR DISTRIBUTION OF ENVIRONMENTAL COSTS ($1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
Ecosystems Analysis																					
Lake Superior					1618																1618
St. Marys River					809																809
Lake Michigan					2428																2428
Lake Huron					2428																2428
St. Clair & Detroit River		(809)*																			
Lake Erie							2428														2428
Lake Ontario							1618														1618
St. Lawrence River							809														809
Wetland Survey	(657)*																				
Fish Spawning/ Nursery Ground Atlas	(177)*																				
Migratory Bird Impact Study		(244)*											125		1142					48	1315
Commercial Fisheries Impact Studies																					
Upper Basin Study						114		29			114		371		57						685
Middle Basin Study								38		10					38		124		19		229
Lower Basin Study								38		10					38		124		19		229
Sport Fisheries Impact Studies																					
Upper Basin Study						114		29			114		371		57						685
Middle Basin Study								38		10					38		124		19		229
Lower Basin Study								38		10					38		124		19		229
Water Quality Study																					
Upper Basin Study									828						48						876
Middle Basin Study												262							28		290
Lower Basin Study												262							28		290

*Studies started and funds committed.
Not included in totals.

Table 8. (Continued)

Annual Environmental Study Costs for System-Wide Studies

FISCAL YEAR DISTRIBUTION OF ENVIRONMENTAL COSTS ($1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	TOTAL
Fish Habitat Impact Studies																					
Upper Basin Study					343		28				229		628			58					1286
Middle Basin Study					114		10							76		209			19		428
Lower Basin Study					114		10							76		209			19		428
Mammal Habitat Impact Studies																					
Upper Basin Study					343		28				229		628			58					1286
Middle Basin Study					114		10							76		209			19		428
Lower Basin Study					114		10							76		209			19		428
Rare or Endangered Species Impact Studies																					
Upper Basin Study					343		28				229		628			58					1286
Middle Basin Study					114		10							76		209			19		428
Lower Basin Study					114		10							76		209			19		428
Oil and Hazardous Substance Contingency Plans																					
Contingency Plan Study					95																95
Hazardous Substance Spill Research					476																476
On Site Spill Incidents																					
Upper Basin Study																5712					5712
Middle Basin Study																		3998			3998
Lower Basin Study																		2285			2285
GRAND TOTALS ALL STUDIES (TABLES 7 & 8)	* (834)	* (1053)	0	0	9567	9367	4999	18489	828	3086	915	2284	12314	15737	18117	12234	6301	11991	246	1285	127760

*Studies started and funds committed.
Not included in totals.

ATTACHMENT A TO APPENDIX E

COE/FWS INTERAGENCY AGREEMENT

Interagency Agreement Between the Department of the Army United States Army Corps of Engineers and the Department of the Interior, United States Fish and Wildlife Service regarding Winter Navigation Feasibility Program Environmental Studies

ARTICLE I AUTHORITIES: This Agreement is entered into under the authority of the River and Harbor Act of 1970 (Section 107 of PL 91-611), Water Resources Development Act of 1974 and 1976 (PL 93-251 and PL 94-587), the Fish and Wildlife Coordination Act 16 USC 661 et seq and NCDPD Regulation No. 1105-2-1 (1 Oct. 1977).

ARTICLE II PARTIES: The parties to this agreement are the United States Army Corps of Engineers, hereinafter referred to as the "Corps", and the United States Fish and Wildlife Service, hereinafter referred to as the "Service."

ARTICLE III PURPOSE: The purpose of this agreement is to specify the arrangements under which the Corps and the Service will cooperate in conducting the environmental studies to determine the feasibility of extending the navigation season on the Great Lakes and the St. Lawrence Seaway.

ARTICLE IV ORGANIZATION: The attached Exhibits:
I - Funding and Program Implementation Organization.
II - Study Products Flow.

Are hereby incorporated and made a part of this agreement. These exhibits shall guide all questions of funding channels, program organization and the production and coordination of authorized Winter Navigation Feasibility Program Environmental Studies.

ARTICLE V OBLIGATIONS: The Service and the Corps agree to the following:

A. The Service shall manage the environmental studies authorized by the Corps.

B. The Corps shall supply the Service with the necessary information to match environmental studies to the engineering and physical activities of Winter Navigation.

C. The Service shall deliver a "Statement of Work" for each environmental study that it manages. The Corps shall review the "Statement of Work" to satisify Corps procurement regulations and insure applicability to proposed engineering and physical activities of Winter Navigation. The "Statement of Work" will contain:
(1) Background information and objectives of the study.
(2) A scope of the work to be performed which shall include a detailed description of the study area, study technique and study analysis.

(3) A description of the reports or deliverables to be produced by the study which shall include a Program and Data Management Plan, Final Product Outline and Format, and Program Progress Reports.

(4) A listing of Required Performance Periods and Delivery Dates of reports and deliverables.

(5) Estimated cost of the study or procurement.

(6) Estimated study initiation date.

D. The Service and the Corps shall establish a Technical Review Committee composed of representatives of the Service and the Corps, and others when determined advisable by the Service or the Corps, to review the Statements of Work and products of the Environmental Studies.

E. The Service shall submit quarterly reports indicating work accomplished and money obligated on each Environmental Study.

F. The Service and the Corps shall jointly review all authorized Winter Navigation Study Reports.

G. The Service shall establish a team to be known as the Environmental Assessment of the Great Lakes/St. Lawrence Ecosystem Team or "EAGLE." The function of EAGLE shall be to refine the Environmental Plan of Action (EPOS) and make specific recommendations for studies to the Corps which it considers essential to an understanding of the environmental impact of Winter Navigation.

H. The Service shall provide for scientific expertise to advise and aid the Technical Review Committee and EAGLE when so requested.

ARTICLE VI <u>PAYMENT</u>: The Corps shall pay the Service for the costs of performing the Environmental Studies, authorized pursuant to this agreement. The Corps shall forward form DD-1144 to the Service, with a signed copy returned to the Corps. Upon mutual agreement of a "Statement of Work," the Corps shall forward form SF-1080 (Advanced Billing w/Certification Statement) to the Service. The signed SF-1080 shall be returned to the Corps and funds shall be sent to the Service. The Service shall return any excess funds to the Corps.

ARTICLE VII TERMINATION: If Termination for the Convenience of the Government is necessary for a study authorized pursuant to this agreement, the Corps shall advise the Service and shall not be liable for any costs associated with continued performance of the study incurred after receipt by the Service of a notice to cease performance. The Corps shall pay the Service for any and all costs associated with Termination for the Convenience of the Government Action.

ARTICLE VIII REPRESENTATIVES: The Corps shall appoint a Corps Project Manager within the Detroit District Corps of Engineers office for the purpose of coordinating funding, planning, organizing and managing of the Environmental Studies with the corresponding Project Manager of the Service as well as coordinating the Environmental Studies with the proposed engineering and physical activities of Winter Navigation.

ARTICLE IX APPROVAL: This Agreement shall take effect upon the day of approval by the Corps and the Service.

Department of the Army
U.S. Army Corps of Engineers
North Central Division

BY: [signature]
General Robert L. Moore

Title: Division Engineer

Date: 2/4/78

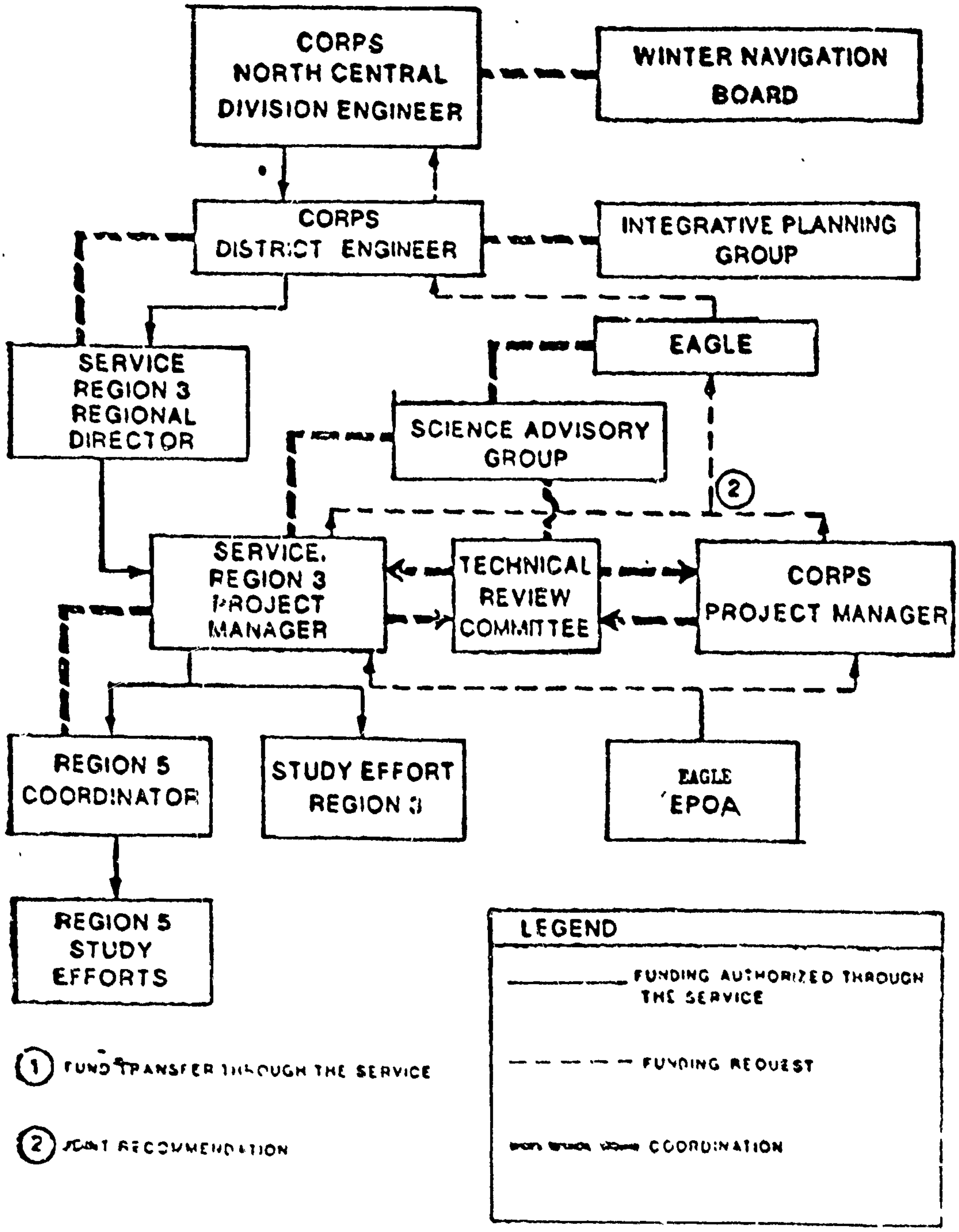
Department of the Interior
U.S. Fish and Wildlife Service

BY: Jack E. Hemphill
Jack E. Hemphill

Title: Regional Director

Date: 2/2/78

Funding and Implementation Organization



ATTACHMENT B TO APPENDIX E

ENVIRONMENTAL STUDIES BY LOCATION

CONTENTS

CONTENTS (Continued)

TABLES

1.0 INTRODUCTION

The combined environmental studies described in this attachment were developed to eliminate the duplication and redundancy that is obvious in the studies described in Attachment C. These new combined studies have been grouped by geographical location. Thus, sites with common developmental concerns, e.g., turbidity and sediment movement from icebreaking and vessel operation, that are in close proximity can be studied and evaluated by a single crew with a single baseline study with data separate for the various sites. The baseline update and monitoring phases of similar COE projects may be combined to further reduce duplication of effort.

This method of grouping assumes the ability of a research team to concentrate their efforts over more than one site-specific investigation. The elimination of redundant study efforts reduces the overall costs for environmental assessment, including manpower and equipment expenses and integration and analysis costs. Although the number of studies may be reduced by up to 80 percent, there will not necessarily by a similar magnitude of reduction in cost, since there are certain parameters that must be evaluated on a development-specific basis which may keep the costs up slightly (e.g., littoral zone evaluation for shoreline protection).

The grouping of studies by geographic location is mainly for the initial baseline information gathering efforts. Each geographic subdivison of the lakes and each stretch of the connecting channels will have one baseline study and baseline evaluation associated with it. Sampling sites for the baseline will be chosen so that later site-specific baseline update and monitoring sampling may be done in the same places to enable comparisons of environmental conditions both before and after project development. The baseline evaluation portion of the environmental studies will attempt to reduce the number of parameters that need to be sampled during the baseline update and monitoring phases since some of the proposed COE developments will not affect certain environmental conditions.

In several instances, the baseline update and monitoring environmental studies are also combined for COE development projects that are located within the same geographic area and have similar sampling parameters. For example, the baseline update and monitoring studies for icebreaking, vessel speed control and shoreline protection are combined for the Bay City-Saginaw Bay region of Lake Huron, since each of these activities will require the sampling of similar physical, chemical and biological parameters. Though the sampling parameters are similar, the data would be kept separate and evaluated separately for the sampling sites within the site specific areas. This study consolidation will lead to further reductions in manpower and funding costs.

The following descriptions characterize the geographical regions or areas with the Great Lakes-St. Lawrence Seaway system that have common baseline studies and present cost estimates for environmental studies associated with the proposed COE developments within each region. The implementation charts which describe the scheduling of the COE navigation projects and FWS environmental studies are presented in Section 5 of the EPOA. More detailed descriptions of environmental concerns and what is to be studied for each development is found in Attachment C under each of the development studies.

2.0 STUDIES

The following are brief descriptions of the combined baseline studies that have been proposed for various sections of the program area. The studies have been grouped according to river segments for the U.S. portions of the connecting channels and the St. Lawrence River and by harbors for the lake developments. The estimated costs for both the area-specific baseline assessments and the grouped projectspecific baseline update and monitoring activities are given in units of $1000 throughout the following sections. These costs and the cost breakdown for each study phase in each geographic area are presented in Tables 1 through 9 at the end of this attachment. In addition, a summary of the environmental study costs for each geographic area and the annual cost breakdowns are given in Tables 5 and 7 of the EPOA.

2.1 Lake Superior

Lake Superior is the largest of the Great Lakes having a length of 350 miles and a maximum width of 160 miles. The lake has a large heat storage capacity which has a pronounced effect upon the ice cover. Upwelling currents change the extent and distribution of ice packs and cause melting wherever they come in contact with the ice cover, even though air temperatures are below freezing. Ice formation begins in January and continues through March.

The following harbor and bay areas have been grouped together for consolidation of environmental study costs for each area).

. Duluth-Superior	$2094
. Ashland-Chequamenon Bay	1380
. Marquette-Presque Isle	1713
Total	$5187

2.1.1 Duluth-Superior

Duluth-Superior Harbor, Minnesota, is located on the border between Minnesota and Wisconsin at the extreme western end of Lake Superior. The shallow depth of the harbor and the prevailing cold temperatures foster rapid ice growth that can reach a thickness of 30 inches. In addition, the adjacent lake area is subject to wind blown rafting that can extend out from the harbor for several miles. At present, the harbor does not normally operate later than mid-January because of severe winter conditions. The estimated environmental baseline assessment cost for Duluth-Superior Harbor is $524.

The three proposed COE developments at Duluth-Superior Harbor requiring environmental assessment are listed below with their estimated baseline update and monitoring costs.

. Icebreaker Mooring Facilities	$333
. Harbor Icebreaking	666
. Air Bubbler System	571
Total	$1570

2.1.2 Ashland-Chequamenon Bay

Ashland Harbor, Wisconsin, is located about 60 miles east of the Duluth-Superior Harbor. The harbor is in a relatively well protected, shallow bay. Ashland experiences the coldest weather of any harbor on the Great Lakes and consequently develops a very heavy ice and snow cover that remains until late spring. Currently, the harbor closes in winter. The estimated environmental baseline assessment cost for Ashland Harbor is $476.

The two proposed COE developments at Ashland Harbor requiring environmental assessment are listed below with their estimated baseline update and monitoring costs.

• Harbor Icebreaking	$333
• Air Bubbler System	571
Total	$904

2.1.3 Marquette-Presque Isle

Marquette Harbor, Michigan, is located on the south shore of Lake Superior adjacent to the City of Marquette. The harbor has a basin area of about 350 acres and is well protected by shoreline to the west and north and by a breakwater on the east.

Presque Isle Harbor, Michigan, is located on the south shore of Lake Superior about three miles north of Marquette, Michigan. The harbor is well protected from prevailing northwesterly winds by Presque Isle Point. At present, the harbor is closed from mid-December to early April. The ice thickness may reach 30 inches in the harbor and dock areas. A level, stable ice cover generally exists in and around the harbor area throughout the winter. The estimated environmental baseline assessment cost for this harbor group is $476.

The two proposed COE developments at these harbors requiring environmental assessment are listed below with their estimated baseline update and monitoring costs.

• Icebreaking	$666
• Air Bubbler System	571
Total	$1237

2.2 St. Marys River

The St. Marys River flows in a southeasterly direction out of Lake Superior through several channels and an extensive locks system to Lake Huron, a distance of 63 to 75 miles depending on the route traversed. Traditionally, navigation ceases about 15 December and does not resume until late March or early April due to shifting ice fields and the blockage of the locks entrance with ice jams.

The St. Marys River has been divided into the following four stretches for purposes of consolidating the baseline environmental studies (shown are the total estimated environmental study costs for each area).

• Whitefish Bay to Locks	$3760
• Locks to Neebish Island	4710
• Neebish Island through Munuscong Lake	4569
• Munuscong Lake to DeTour	809
Total	$13848

2.2.1 Whitefish Bay to Locks

The first stretch of the St. Marys River encompasses approximately 35 miles of waterway from Whitefish Bay, the outlet of Lake Superior, to the locks at Sault Ste. Marie. Shifting ice fields are common in this area from the action of wind, current and ship traffic, and shoreline erosion and structure damage may occur. Also, considerable effort is required for winter lock operation due to jamming and accumulation of ice fragments as ships plow through the lock entrance. The baseline environmental studies for this segment of the St. Marys River will have an estimated total cost of $1190.

Each of the four COE developments proposed for this segment of the St. Marys River which will require environmental studies has been placed into one of the two baseline update and monitoring studies. These estimated developments and their costs for baseline update and monitoring studies are listed below.

• Icebreaking Activities Vessel Speed Control Shoreline Protection	$1999
• Air Bubbler Systems	571
Total	$2570

2.2.2 Locks to Neebish Island

Flow through this stretch of the river, as well as the rest of the St. Marys River, is regulated by the locks system according to the water level of Lake Superior. Ice jams may occur in the slower moving water of Little Rapids Cut and Lake Nicolet, forming ice ridges greater than 15 feet in thickness. Sugar Island, located just downstream of Soo Harbor, is about 15 miles long with a maximum width of 8½ miles. The island has about 450 permanent residents, and travel to and from the island is by ferry. The baseline environmental studies cost for this stretch of the St. Marys River are estimated to be $1285.

Each of the five proposed COE developments requiring environmental assessment for this river segment has been placed into one of three baseline update and monitoring studies. These developments and their estimated environmental study costs are listed below.

•	Icebreaking Activities Shoreline Protection Vessel Speed Control	$1713
•	Ice Control Structures	856
•	Air Bubbler Systems	856
	Total	$3425

2.2.3 Neebish Island through Munuscong Lake

Neebish Island which is located just downstream from Sugar Island is about four miles long and two miles wide. It is bounded on the Canadian side by the upbound Middle Neebish Channel and on the United States side by the downbound West Neebish Channel. The island has a number of summer homes but has a small winter population of 30 to 50 residents.

The West Neebish Channel is about 9000 feet long and 300 feet wide. About one mile of the channel is rectangular in shape and cut through rock, an area commonly called the Rock Cut.

Traditionally, any winter navigation is restricted to the Middle Neebish Channel. The U.S. Coast Guard announces when the West Neebish Channel will no longer be used based on conditions encountered by the Neebish Island ferry with early ice. Once the channel is closed, Island residents travel back and forth on the ice just upstream and downstream of the Rock Cut Channel. Downbound ship traffic is diverted to the Middle Neebish Channel and controlled by the Coast Guard at Sault Ste. Marie until traffic stops for the winter. Traffic control is necessary since there is only room for one-way traffic in the channel at any given time. Problems are encountered with downbound loaded traffic in the Middle Neebish Channel due to tight turns, shallow depths and strong currents. The baseline environmental studies for this stretch of the river will have an estimated cost of $1238.

Each of the five proposed COE developments for this river segment that will require environmental assessment has been placed into one of three baseline update and monitoring studies. These developments and their estimated costs for baseline update and monitoring are listed below.

•	Icebreaking Activities Shoreline Protection Vessel Speed Control	$1332
•	Air Bubbler Systems	714
•	Dredging	1285
	Total	$3331

2.2.4 Munuscong Lake to DeTour

The river segment from Munuscong Lake to DeTour includes two major islands and the DeTour Passage. Shifting ice fields occur naturally in this region as a result of changing wind and weather conditions.

Lime Island, located about 35 miles downstream from Sault Ste. Marie, is separated from the mainland by three miles of water. The principal activity on this U.S. island is the operation of a fueling station for freighters which stop during the regular season and general maintenance during the winter. About 10 adults live on the island during the winter months to maintain the island facilities. Transportation to the island is by small tug boat during the regular navigation season and by foot or snowmobile after heavy ice has formed.

Drummond Island is located at the lower end of the St. Marys River wh[illegible] it enters Lake Huron. It is separated from the Michigan mainland by the mile- [illegible]e DeTour Passage. The island supports the Drummond Dolomite Quarry, summer recreational facilities, and about 600 permanent residents. Ferry traffic to Drummond Island is occasionally disrupted by ice floes which jam in the DeTour Passage, particularly when Lake Huron ice is blown into the area by southerly winds. Wind also blows loose ice against the shoreline and into the ferry slips which occasionally hampers docking operations. The estimated cost of the baseline environmental studies for this region of the river is $238.

The only proposed COE navigation project requiring an environmental assessment for this river stretch is a pilot access development with an estimated baseline update and monitoring cost of $571.

2.3 Lake Michigan

Lake Michigan, because of its north-south orientation and 300 mile length (118 miles maximum width), can have ice formation and deterioration simultaneously. The period of extensive ice formation begins about the last week of January and continues until around the third week of March. During a severe winter, ice may cover 80 percent of the surface. Generally the northern half of the lake contains the heaviest ice concentration throughout the winter.

The following seven harbor and bay areas have been grouped together for consolidation for environmental studies (shown are the total estimated environmental study costs for each area).

• Green Bay Harbor -Green Bay - Escanaba	$3903
• Milwaukee	904
• Calumet	1047
• Indiana Harbor -Burns Harbor - Gary	1095
• Muskegon - Muskegon Lake	2761
• Ludington	1665
Total	$11,375

2.3.1 Green Bay Harbor - Green Bay - Escanaba

Green Bay Harbor, Wisconsin, located about a 3.5 mile reach of the Fox River, has 37 docks which are used to ship a wide variety of products. Navigation usually ceases in mid-December and resumes in late March. Ice in the harbor and along the docks generally forms a uniform cover 18 to 24 inches thick. The main area of Green Bay is subject to ice ridges and windrowed ice from the predominant northwesterly winds throughout the winter. The entrance to the harbor generally remains open because of a thermal discharge from the local sewage treatment plant. The total estimated environmental baseline assessment cost for this harbor group is $1190.

Each of the four proposed COE developments for this area requiring environmental assessment has been placed into one of two baseline update and monitoring studies. These developments are listed below with their estimated baseline update and monitoring costs.

• Shoreline Protection Harbor Icebreaking Vessel Speed Control	$1952
• Icebreaker Mooring Facilities	761
Total	$2,713

2.3.2 Milwaukee

Milwaukee Harbor, Wisconsin, is a large port area which has traditionally been used by car ferries and local tankers throughout the winter. The predominant westerly winds tend to keep the western shores of Lake Michigan, including the harbor area, ice free most of the winter. Frequent ship traffic keeps a track open within the harbor where refrozen brash is generally less than six inches in thickness. The estimated environmental baseline assessment cost for Milwaukee Harbor is $238.

The proposed COE development at Milwaukee Harbor that will require environmental assessment are the Icebreaking. The estimated baseline updafe and monitoring cost for this operation is $666.

2.3.3 Calumet

Calumet Harbor, Illinois and Indiana, is located about 12 miles south of Chicago Harbor. Ice conditions in this region of the lake are similar to that near Chicago Harbor. Wind blown ice will temporarily compact up to 20 feet and extend into the lake for miles umtil there is a shift or change in intensity. Ice in the Calumet River rarely exceeds six inches but may grow up to two feet thick in Lake Calumet

Traditionally, there has been year-round barge traffic in the Calumet River and to southern Lake Michigan ports. The estimated environmental baseline assessment cost for this harbor group is $476.

The proposed COE development at these harbors requiring environmental assessments is listed below with its estimated baseline update and monitoring costs.

•	Air Bubbler Systems	571
	Total	571

2.3.4 Indiana Harbor - Burns Harbor - Gary

Indiana Harbor, Indiana, located about seven miles southeast of Calumet Harbor, consists of an inner and outer harbor. The entire harbor and canal is usually ice free due to a thermal discharge from Inland Steel. Ice conditions outside of the harbor are more typical of southern Lake Michigan. Wind driven pack ice can extend into the lake for miles, lasting for periods of several hours to several days. This condition can occur several times throughout the winter.

Burns Waterway Harbor, Indiana, normally is open year-round to tug-barge traffic. There are few ice problems in the harbor. Most problems occur in the lake with wind driven pack ice temporarily blocking the harbor until there is a shift in the wind. This condition usually lasts one to two days and occurs several times during the winter.

Gary Harbor, Indiana, is generally ice free most of the winter because of a thermal discharge from the local steel mills. The area outside of the harbor is subject to wind blown ice jams similar to those described above. These conditions average two days in January, 4.5 days in February, seven days in March with an average duration of 1.5 days and maximum during of five days. The estimated environmental baseline assessment cost for this harbor group is $429.

The only proposed COE developments at these harbors that will require environmental assessment are the ice control structures. Their estimated baseline update and monitoring cost is $666.

2.3.5 Muskegon - Muskegon Lake

Muskegon Harbor, Michigan, is located in Muskegon Lake, just inland from Lake Michigan. Entrance into the harbor is through a 200 feet wide channel protected by breakwaters extending into Lake Michigan. The ice in Lake Muskegon is generally uniform, growing up to two feet thick outside of the navigation track. Ice conditions at the harbor entrance and into the lake are typical of other southern Lake Michigan areas. Wind driven ice may temporarily build up to 15 feet in thickness and extend into the lake for miles. A wind shift will usually clear the area or loosen the ice pack. The estimated environmental baseline assessment costs for this area is $952.

Each of the three proposed COE developments for Muskegon Harbor that will require environmental assessment has been placed into one of two baseline update and monitoring studies. These developments are listed below with their estimated baseline update and monitoring costs.

• Ice Control Structures	$619
• Vessel Speed Control Harbor Icebreaking	1190
Total	$1809

2.3.6 Ludington

Ludington Harbor, Michigan, is located in Pere Marquette Lake just inland from the Lake Michigan shoreline. The outer basin in the lake is enclosed by two converging breakwaters. Car ferries have traditionally operated year-round. Ice can grow to two feet thick in the harbor and connecting channel outside of the navigation track. Ice conditions at the harbor entrance are similar to other harbors in the area. Pack ice will be temporarily blown into windrows, extending for several miles into the lake, until winds shift and loosen the jam. The estimated environmental baseline assessment cost for Ludington is $666.

The two proposed COE developments at Ludington Harbor that will require environmental assessment are listed below with their estimated baseline update and monitoring costs.

• Harbor Icebreaking	$666
• Ice Control Structures	333
Total	$999

2.4 Lake Huron

Lake Huron has a north-south orientation similar to Lake Michigan, but is considerably wider (maximum width 183 miles) and has a cooler, more uniform temperature differential over its 206 mile length. Traditionally, navigation ceases on this lake during the ice season from mid-December to late March.

Lake Huron has large areas that are protected from deep lake currents with Georgian Bay tending to react to ice formation as an individual lake. Lake Huron proper has three areas that form and accumulate extensive ice covers early in the season: the Straits in the north; Saginaw Bay; and the southern basin in the Port Huron area.

During a normal ice season, 60 percent of the lake becomes ice covered. In a severe winter, the lake may become 80 percent ice covered. The southern basin, because of the surface current pattern, collects large amounts of drifting ice that can become concentrated at the entrance to the St. Clair River near Port Huron.

The following two harbor and bay areas have been grouped together for consolidation of environmental studies (shown are the total estimated environmental study costs for each area).

• Alpena - Thunder Bay	$2808
• Bay City - Saginaw Bay	4143
Total	$6951

2.4.1 Alpena - Thunder Bay

Alpena Harbor, Michigan is located on the northwest shore of Thunder Bay in northern Lake Huron. The harbor comprises the lower reach of Thunder Bay River and a reach in the Bay containing major industrial docks. The harbor is generally closed during the coldest part of the winter, January through March.

Ice conditions vary from year to year. Heaviest conditions occur when southeasterly winds pack the harbor with ice floes up to three feet in thickness. Northwesterly winds tend to blow the harbor ice into Lake Huron. The river ice is usually stable with an estimated thickness of one foot in a severe winter. During most winters, the bay is open except for periods of jammed or windrowed lake ice which may last from a few days to several weeks. The estimated environmental baseline cost for this harbor group is $809.

The three proposed COE developments at these harbors that will require environmental assessment are listed below with the estimated baseline update and monitoring costs.

• Vessel Speed Control Harbor Icebreaking	$1333
• Air Bubbler System	666
Total	$1999

2.4.2 Bay City - Saginaw Bay

Ports on the Saginaw River, Michigan, are located along about 17 miles of the river at the cities of Essexville, Bay City, Milwaukee, Carrollton, and Saginaw. The river is closed to navigation during the winter months. Ice conditions in the river are minor, but a level ice cover up to one foot thick may develop during a severe winter. However, there are numerous weak spots and openings due to thermal discharges from local industrial and municipal facilities. The worst ice conditions exist outside of the river in Saginaw Bay where ice can grow to two feet thick levels and windrow up to six feet thick. The bay is also used for recreation, primarily ice fishing and snowmobiling. The estimated environmental baseline cost for this area is $1428.

Each of the five proposed COE developments at Bay City Harbor that will require environmental assessment has been placed into one of three baseline update and monitoring studies. These developments and their estimated baseline update and monitoring costs are listed below.

•	Harbor Icebreaking Vessel Speed Control Shoreline Protection	$905
•	Icebreaker Mooring Facilities	905
•	Ice Control Structures	905
	Total	$2715

2.5 St. Clair River

The St. Clair River flows for a distance of about 39 miles from Lake Huron to Lake St. Clair. Lake St. Clair extends between the mouth of the St. Clair River and the head of the Detroit River (a distance of about 18 miles) and occupies a shallow basin having an average depth of about 10 feet, with low, marshy shores in undeveloped areas. The shallow depth requires a dredged commercial navigation channel 27.5 feet deep and 800 feet wide throughout its length.

Historically, the St. Clair River does not generally freeze over because of the swift current throughout its length and several thermal discharges from adjacent plants. However, the lower end is frequently covered with broken ice drifting down from Lake Huron and from shore ice generated within its boundaries. An ice cover (bridge) generally forms across the head of the river which stops the inflow of additional ice. However, this ice bridge is occasionally broken by strong winds or mid-winter and spring thaws which allow additional ice to flow downstream and jam in the lower river.

Ice jams in the lower river vary in magnitude from year to year. During a mild winter, the ice cover may only back upstream from Lake St. Clair one or two miles. A severe winter has caused ice to jam nearly the entire 39 mile length of the river. The presence of an ice cover causes a retardation in flow through the system. If strong winds and current cause the ice cover to layer and compact in thickness, a

serious ice jam may develop which has caused upstream flooding in the Marine City-Algonac area. The jam also hampers the limited navigation through the area in addition to several ferry operations which continue year-round across the river.

For purposes of combining environmental study efforts, the St. Clair River has been divided into four sections listed below (shown are the total estimated environmental study costs for each area).

• Blue Water Bridge to St. Clair Harbor	$5855
• St. Clair to Marine City	1380
• Marine City to Algonac	2856
• Algonac to Lake St. Clair	2237
Total	$12328

2.5.1 Blue Water Bridge to St. Clair Harbor

At the mouth of the St. Clair river near Port Huron, Michigan, an ice bridge occurs naturally during mid-winter. The ports of Marysville and Port Huron in this stretch of river remain relatively ice free throughout most of the winter, except for occasional ice floes moving down from Lake Huron. The pilot transfer point at Port Huron, Michigan, is located downstream of the Blue Water Bridge on the American side of the St. Clair River, and this section of the river is relatively free of ice during the winter months. The cost of the baseline assessment for this river segment has been estimated at $2047.

Each of the following five proposed COE developments will require environmental assessment and has been placed into one of three baseline update and monitoring studies. These developments are listed below with their estimated costs for baseline update and monitoring.

• Icebreaking Activities Vessel Speed Control Shoreline Protection	$1523
• Ice Control Structures	762
• Compensating Works	1523
Total	$3808

2.5.2 St. Clair Harbor to Marine City

The river stretch from St. Clair to Marine City is similar in physical and chemical characteristics to the upper stretch of the St. Clair River. Relatively ice-free conditions prevail at the port of St. Clair and along most of this segment of the St. Clair River during the winter months due to the swift currents. The baseline environmental assessment cost for this section of the St. Clair River is estimated at $571.

The only proposed COE development for this river segment requiring environmental assessment is vessel speed control with an estimated baseline update and monitoring cost of $809.

2.5.3 Marine City to Algonac

Ice jams have continued to be a problem in the lower St. Clair River, particularly during February 1973 and March 1975 when there was significant flooding in the Algonac-Marine City area. This problem was compounded by the near-record high lake levels that have prevailed throughout the system in recent years. The ice jams resulted from unusually large quantities of ice that entered the river from Lake Huron after strong winds and thaw conditions broke up the stable ice cover. Southern winds blew the ice cover north into Lake Huron, then strong northern winds blew the broken ice floes back into the river. Numerous homes were flooded in the low-lying areas adjacent to the river.

Generally, dock and shore structure damage occurs during periods of heavy ice jams. Damage has also been reported by dock owners along the St. Clair River resulting from the wakes of passing vessels moving broken ice against and under the structures during periods of significant ice. This causes the structural components to be lifted up, pushed back, or sheared off with resultant property damage.

There have also been isolated cases of shoreline erosion caused by ice piling on shore, generally resulting from the natural effect of wind and current. Much of the shoreline is protected by steel, stone, and wood seawalls. Recent high lake levels have caused extensive erosion along the highway opposite the Algonac State Park. A series of rock-filled gabions have been effective in stabilizing this stretch of shoreline. The baseline study efforts for this stretch of the St. Clair River have an estimated cost of $1047.

The three proposed COE developments that will require environmental assessment are listed below with their estimated cost for baseline update and monitoring.

- Icebreaking Activities
  Vessel Speed Control $1809
  Shoreline Protection

2.5.4 Algonac to Lake St. Clair

Ice jams are also a problem in this stretch of the St. Clair River. During the periods of flooding in the Algonac-Marine City area, a solid ice jam formed over the lower river from Lake St. Clair upstream 15 to 16 miles to Marine City. The northern winds compacted the ice into layers several feet thick in many areas. This heavy ice jam has persisted through most of the winter during three of the seven winters of the Demonstration Program, requiring frequent icebreaker assistance for ships stuck in the ice. Ice jams are frequent and severe enough to halt shipping and clog channels for days or possibly weeks.

Dock and shore structure damage has occurred in the Algonac area and along Harsens Island when large ice floes collect around a structure and freeze together in a large mass. Occasionally, this ice will move under the forces of wind, current,

winter navigation, or icebreaking activities and cause damage to the structure. The estimated cost for environmental baseline assessment for this section of the St. Clair River is $857.

The two proposed COE developments for this segment of the St. Clair River that will require environmental assessment are listed below with their estimated cost for baseline update and monitoring:

- Vessel Speed Control Shoreline Protection — $1380

2.6 Lake St. Clair

Lake St. Clair lies between the St. Clair and Detroit Rivers. The shallow depth and small surface area of the lake cause it to react quickly to wind conditions and all temperature changes. The prevailing winds, currents, and inflow from the various channels of the St. Clair River affect the ice cover which accumulates much faster in the eastern half of the lake. The lake usually becomes ice covered during the last part of January, and normally remains frozen over much of the winter, and vessel traffic is confined to a 1000 foot wide navigation channel that is dredged to a 27 foot depth through the length of this shallow lake. During the period of greatest ice cover, the distribution varies from thick fast ice in the bays and protected areas to heavy, consolidated floes of brash and cake ice in the mid-lake shipping channel.

The breakup period of the Lake St. Clair ice cover is short. As breakup progresses, winds and currents move the drifting ice to the entrance of the Detroit River, where strong river currents move it downstream. The western side is the first area to be cleared of ice. The lake is usually ice free in early March. The environmental baseline assessment for Lake St. Clair is estimated at $714.

The two proposed COE developments for Lake St. Clair that will require environmental assessment are listed below with their estimated cost for baseline update and monitoring.

- Icebreaking Activities Vessel Speed Control — $1190

The total cost for all environmental studies for Lake St. Clair is estimated at $1907.

2.7 Detroit River

The Detroit River extends from its head at Windmill Point Light, Lake St. Clair, and flows in a southerly direction for 32 miles to Lake Erie. The river is divided into 3 sections for purposes of consolidating environmental studies (shown are the total estimated environmental study costs).

• Head of Peach Island to Rouge River	$5712
• Rouge River to Trenton	2237
• Trenton to Point Mouillee	2856
Total	$10805

2.7.1 Head of Peach Island to Rouge River

The head of the Detroit River is usually ice free the entire season except for minor jamming when drift ice becomes concentrated in the area. An ice bridge usually forms across the head of the Detroit River upstream of Peach Island. The edge of the ice bridge tends to erode upstream during strong wind or thaw conditions, allowing loose ice to enter the river. The quantitites of floe ice vary from year to year depending on weather conditions. During periods of wind and thaw conditions, the ice bridge will fracture and erode back into Lake St. Clair, causing large ice floes to drift downstream and occasionally jam in the lower river.

This stretch of the Detroit River does not normally freeze over because of its narrow channel and swift current. One exception is the broad, shallow area between Belle Isle and the U.S. mainland.

Two railroad car ferries operate year-round across the upper river between Detroit, Michigan, and Windsor, Ontario. In addition, there are unscheduled operations across the river with tug-barge type vessels carrying oil and salt to various docks up and down the river. The estimated cost for the environmental baseline assessment of this stretch of the Detroit River is $2095.

Each of the six proposed COE developments that will require environmental assessment has been placed into one of four baseline update and monitoring studies. These developments are listed below along with their estimated costs for baseline update and monitoring.

• Ice Control Structures	$571
• Compensating Works	1142
• Vessel Speed Control Shoreline Protection	1142
• Icebreaking Mooring Facilities Pilot Access	762
Total	$3617

2.7.2 Rouge River to Trenton

Conditions in this stretch of river are similar to the upper reach of the Detroit River and are also generally ice free because of the swift current. In addition, there are no significant ice problems at the docking and berthing areas. Occasionally, docks may be surrounded by a thin layer of level ice or a layer of loosely packed broken-up floes, but this does not hamper operations. Occasional ice jams may occur in this stretch that will temporarily halt or slow down navigation until Coast Guard icebreakers can reopen the channel. The estimated cost of conducting the environmental baseline assessment in this section of the Detroit River is $857.

The two proposed COE projects requiring environmental studies are listed below with their estimated cost for baseline update and monitoring.

• Shoreline Protection Vessel Speed Control	$1380

2.7.3 Trenton to Point Mouillee

This lower section of the Detroit River tends to freeze over where the river widens into a series of channels and shallow areas and is subject to ice jams resulting from drifting ice floes from Lake St. Clair. Winter navigation is restricted to the dredged, diked Livingstone Channel which also allows floe ice to enter Lake Erie. If easterly winds blow Lake Erie ice into the lower end of the Detroit River, ice jams can temporarily plug the Livingstone Channel. The ice jams both hamper navigation and cause water levels to rise upstream.

However, upstream flooding does not appear to be a serious problem. Most shoreline development is designed to tolerate occasional high levels resulting from windblown water backing upstream from Lake Erie during the open water season. Similarly, shoreline erosion does not appear to be a serious problem since most of the shoreline is protected against the current, waves, and changing water levels by some form of steel, wood, or rock armor. The estimated environmental baseline assessment cost for this section of the Detroit River is $1047.

The three proposed COE developments that will require environmental assessment are listed below with their estimated cost of baseline update and monitoring.

- Icebreaking Activities
  Vessel Speed Control $1809
  Shoreline Protection

2.8 Lake Erie

Lake Erie is the shallowest of all the Great Lakes and has an average depth of 62 feet. It is considerably smaller than Lakes Superior, Michigan, and Huron, with a length of 240 miles and a maximum width of 57 miles.

Lake Erie reacts rapidly to seasonal temperature changes and, due to its shallow depth, is the most thermally unstable of the Great Lakes. Because of the rapid response to air temperatures, the lake can accumulate an ice cover in a short period. Lake Erie normally develops the most extensive ice cover of any of the Great Lakes, with first ice forming in the shallow, western basin. The ice cover begins to accumulate in early January and is usually at its maximum by the last week of February. Under the influence of currents and winds, the ice cover shifts, causing rafting and pressure ridges to form. During a winter season with normal temperatures, it is possible for the Lake to become 95 to 100 percent ice covered.

The ice cover is made up of various ice types and concentrations. The western basin contains heavy, winter ice, while the area of the lake located between Sandusky, Ohio, and Erie, Pannsylvania, generally contain vast floes and fields of pack ice of differing concentrations. The eastern basin usually has extensive areas of consolidated floes that are concentrated by the prevailing winds and currents.

The following harbor and bay areas have been grouped together for consolidation of environmental studies (shown are the total estimated environmental study costs).

•	West Basins	$1095
•	Monroe - Toledo	2474
•	Sandusky - Sandusky Bay - Huron - Lorain	5093
•	Cleveland	1713
•	Ashtahula - Conneaut	2189
•	Buffalo	1475
	Total	$14,039

2.8.1 West Basin

The West Basin of Lake Erie is that part of Lake Erie being west of the Bass Islands, Pelee Island, and Pt. Pelee. This basin is relatively shallow, averaging less than 30 feet and for this reason is susceptible to wide temperature range. The two largest inflows are the Detroit River and the Maumee River at Toledo. The prevailing winds, currents, and inflows affect the ice formation in this portion of Lake Erie. The ice normally is more than one foot thick during the coldest time of winter.

The subbasin is so shallow that the navigation courses in this subbasin need to be swept of rocks and debris so that the minimum depth of 28 feet is maintained. Thus, the propeller wash and the associated currents have an adverse effect on the bottom sediments and the animals that use this habitat. This is especially true when the vessel tracks in the ice move for various reasons.

The breakup period of the West Basin is relatively short. At breakup, winds and currents move the drifting ice around so harbor entrances are sometimes blocked by ice. Sometimes the ice is piled into deep pressure ridges at the harbor entrances causing the ships to have difficulty in entering the harbor.

The only proposed COE development that will require environmental assessment in the West Basin of Lake Erie is the icebreaking activity. The baseline assessment cost for this activity is estimated at $429. The baseline update and monitoring cost is estimated at $666.

2.8.2 Monroe - Toledo

Monroe Harbor, Michigan, located in the mouth of the River Raisin about 15 miles north of Toledo, Ohio, is normally closed to shipping January through March. The ice cover in the navigation channel consists of solid shorefast ice that may reach 12 inches in thickness; but it may reach two feet in thickness at the harbor entrance. On rare occasions, windrows will form outside the harbor entrance when strong easterly winds blow the ice field against the shoreline.

Toledo Harbor, Ohio, is located in the mouth of the Maumee River at the western end of Lake Erie. Coal is normally shipped year-round to power plants along the Detroit River. Ice conditions in the harbor range from nine inches of level ice in the navigation channel to level ice up to two feet thick in the harbor entrance. The baseline assessment cost for these two harbors is estimated at $761.

The three proposed COE developments for these harbors that will require environmental assessment are listed below with their estimated baseline update and monitoring costs.

• Icebreaker Mooring Facilities	$619
• Harbor Icebreaking	714
• Air Bubbler Systems	380
Total	$2474

2.8.3 Sandusky - Sandusky Bay - Huron - Lorain

Sandusky Harbor, Ohio, is located on shallow Sandusky Bay and this bay is located on the westbasin of Lake Erie, about 55 miles west of Cleveland, Ohio. A dredged channel extends from deep water across the bay to the docks and turning basin. Ice conditions in Sandusky Bay and Harbor are generally stable with ice thickness ranging between open water conditions and 20 inches. depending on the severity of the winter. Normally, ice cover is between eight and 10 inches thick.

Huron Harbor, Ohio, is located on the deeper middle basin of Lake Erie, at the mouth of the Huron River, about 47 miles west of Cleveland, Ohio. The normal shipping season is from early April to late December. Major commodities shipped at this harbor are iron ore, limestone, and soybeans. The inner harbor usually forms a stable ice cover that may reach 20 inches in thickness. In addition, occasional ice jams and windows may form across the entrance channel. This condition is usually temporary, rarely lasting more than five days before offshore winds blow the jammed ice back into the lake.

Lorain Harbor, Ohio, is located at the mouth of the Black River, about 28 miles west of Cleveland, Ohio. The port consists of an outer harbor protected by a series of converging breakwaters and an outer harbor protected by a series of converging breakwaters and an inner harbor including the lower three miles of the Black River. Ice conditions in the river and harbor can reach a maximum thickness of two feet. Ice conditions at the harbor entrance vary with the wind conditions. Southwesterly winds will cause drifting lake ice to jam and windrow, at times reaching to the channel bottom. This condition rarely exists more than a few days, but on rare occasions may last up to a month. The estimated cost for environmental baseline assessment for this harbor group is $1761.

Each of the four proposed COE developments for these harbors that will require environmental assessment has been placed into one of three baseline update and monitoring studies. Because of the difference in biological makeup between the west basin of Lake Erie and the middle basin, the data for the Sandusky complex and the data for Huron and Lorain would be kept separate. The funding and study time would be proportionally allocated, with Sandusky complex receiving the greater amount because of its greater biological importance. These developments are listed below with the estimated baseline update and monitoring costs.

- Harbor Icebreaking
  Vessel Speed Control $1334
- Ice Control Structures 999
- Air Bubbler Systems 999

Harbor Icebreaking Vessel Speed Control	$1334
Ice Control Structures	999
Air Bubbler Systems	999
Total	$3332

2.8.4 Cleveland

Cleveland Harbor, Ohio, consists of an outer harbor, that extends along the lake front for five miles, and an inner harbor, consisting of 5.8 miles of the Cuyahoga River and one mile of the Old River. The harbor is normally closed to navigation January through March.

The Cuyahoga River rarely freezes over due to the heated effluent from the steel mills upriver. Ice thickness in the outer harbor is usually less than 18 inches but may reach 24 inches in a severe winter. Ice conditions at the harbor entrance are dependent on wind conditions. Ice jams up to 16 feet thick have been reported. These conditions rarely last more than four days at a time before winds shift and blow the ice away from the harbor. The environmental baseline assessment for Cleveland Harbor has an estimated cost of $571.

The two proposed COE developments for Cleveland Harbor that will require environmental assessment are listed below with their associated baseline update and monitoring costs.

• Icebreaker Mooring Facilities	$666
• Ice Control Structures	476
Total	$1142

2.8.5 Ashtabula - Conneaut

Ashtabula Harbor, Ohio, located about 59 miles northeast of Cleveland, Ohio, consists of a protected outer harbor and an inner harbor extending about two miles up the Ashtabula River. The harbor is normally closed three to four months each winter. Ice conditions in the inner harbor and river usually consist of loose ice floes up to 12 inches thick. Ice in the outer harbor rarely exceeds two feet in thickness. Ice jams extending to the channel bottom can temporarily form at the harbor entrance during periods of strong onshore winds. This condition is transient, and southerly winds will eventually move the ice jams into the lake. The baseline assessment cost for this harbor group is estimated at $857.

The only proposed COE developments for Astabula Harbor and Conneaut Harbor that will require environmental assessment are ice control structures. Each harbor will have a separate baseline update and monitoring study. The total estimated cost for these studies is $1332.

2.8.6 Buffalo

Buffalo Harbor, New York, consists of about 4.5 miles of lakeshore protected by breakwaters, plus sections of the Buffalo River, the Niagara River, and several short ship canals. Ice conditions within the harbor range from open water in the south end, resulting from industrial thermal discharge, to a maximum thickness of two feet toward the north end of the harbor. The heaviest ice conditions exist outside the north harbor entrance. An ice boom across the Niagara River, downstream of the north entrance, prevents ice from proceeding down the river and causes it to back up in the lake. The ice tends to layer and forms a heavy jam through most of the winter. The south entrance is protected by the south pier and tends to remain open because of the thermal discharge. The Black Rock Canal and the channel to Tonawanda will freeze over during a severe winter with a level ice thickness of about one foot. During the spring breakup, the eastern end of Lake Erie is usually filled with brash ice blown in by the prevailing winds. This condition often lasts until May and contains the last ice to leave the area. The estimated cost for environmental baseline assessment for this harbor is $238.

The proposed COE developments for Buffalo Harbor that will require environmental assessment are harbor icebreaking activity and icebreaker mooring facilities. The estimated baseline update and monitoring costs for this development is $1,237.

2.9 Lake Ontario

Lake Ontario, the Great Lake immediately upstream of the St. Lawrence River, is also the smallest with a length of 193 miles and a maximum width of 53 miles.

Lake Ontario has the smallest surface area of all the Great Lakes, but has a mean depth that is second only to Lake Superior. The combination of small surface area and great depth gives this lake a large heat-storage capacity, causing it to respond slowly to changing air temperatures. This response to climatic change affects the amount of ice cover produced, which is the smallest amount of any of the Great Lakes.

An extensive ice cover formation does not appear until late January and is confined to the east end of the Lake. Under normal conditions, the greatest extent of ice cover occurs near the middle of March and occupies 15 percent of the lake surface.

Ice covers about 25 percent of the lake surface during a severe winter. The ice cover is generally fast ice and the prevailing winds and currents tend to confine and concentrate the ice cover at the northeastern end of the lake and the approaches to the St. Lawrence River. The lake is generally ice free early in April except for isolated drift ice and ice in some protected bays.

The following three harbor and bay areas have been grouped together for consolidation of environm-ntal studies (shown are the total estimated environmental study costs).

•	Oswego	$904
•	Cape Vincent	904
	Total	$1,808

2.9.1 Oswego

Oswego Harbor, New York, is located about 45 miles south of the head of the St. Lawrence River. The harbor is the terminus of the Oswego Canal, of the New York State Barge Canal System, and consists of an outer harbor enclosed by a breakwater and an inner terminal harbor in the Oswego River. The normal navigation season corresponds to the opening and closing of the Welland Canal and the Seaway.

Occasionally, a serious ice jam problem will develop at the harbor entrance when southwesterly winds cause ice to layer into thick windrows. This condition is transient, but may last from a few days to a few weeks until offshore winds shift the ice back into the lake. Ice conditions in the harbor and dock areas are minimal due to the river current and power plant thermal discharge. The environmental baseline assessment cost has been estimated at $238 for Oswego Harbor.

The only proposed COE developments for Oswego Harbor that will require environmental assessment are the ice breaking mooring facilities. Their estimated baseline update and monitoring cost is $666.

2.9.2 Cape Vincent

Cape Vincent is located very near the origin of the St. Lawrence River at Lake Ontario. It is located on the New York mainland bluff adjacent to Wolfe Island where the river is relatively constricted by the island. Currents are strong and the river relatively deep. The present pilot facilities are located in a small bay on the point within the town.

This is a well known recreation area with fishing and boating facilities available. The fish landed here include large-mouth and small-mouth bass, Northern Pike, Walleye, perch, and Muskellunge. This town is at the western edge of the famous Thousand Islands area. The water quality coming out of Lake Ontario is good. The river bottom is quite rocky in this vicinity.

The environmental concerns for the Cape Vincent area would be the same as for other areas with icebreaker mooring facilities and where icebreaking will occur, however, the large ships will not be moving very fast because this is the pilot pickup point. The berthing facilities would require more area than that of launches used previously. The environmental study cost for baseline assessment has been estimated at $238.

The two proposed COE developments for Cape Vincent Harbor that will require environmental assessment are listed below with their estimated baseline update and monitoring cost.

- Pilot Access
  Icebreaker Mooring Facilities $666

2.10 St. Lawrence River

The St. Lawrence River flows northeast 530 miles from Lake Ontario to its mouth at Father Point, Quebec. The winter ice-cover usually forms first along the south shore canal between Montreal and Lake St. Louis in early to mid-December and advances upriver to Lake Ontario. Mid-winter conditions usually consist of fast ice which is not generally subjected to breakup from wind or current conditions. Ice thickness in channel sections may average two to three feet while lake and river ice may only reach a thickness of 1.5 to 2.5 feet.

With improvements in icebreaking and ice control works the season in the most easterly Canadian section of the St. Lawrence River is open to shipping on a year-round basis. However, the westerly portion, from Lake Ontario to Montreal Harbor, is closed to navigation from mid-December to early April for two primary reasons. First, ice in the river presents a major obstacle to ship movement and could prevent ship passage. Second, ice jams could impact on power generation at the major Moses-Saunders hydroelectric generating station that exists in this portion of the river.

For the purposes of conducting baseline environmental studies, the U.S. portion of the St. Lawrence River has been divided into the following sections (shown are the total estimated environmental study costs.

• Cape Vincent to Alexandria	$3569
• Alexandria through Ogdensburg	4950
• Ogdensburg to Massena	4856
Total	$12518

2.10.1 Cape Vincent to Alexandria

This stretch of the St. Lawrence River flows northeasterly from the town of Cape Vincent at the outlet of Lake Ontario to Alexandria, a distance of approximately 25 miles and includes the Thousand Islands area. The river in this area is closed to navigation from mid-December to early April due to ice cover. Year-round residents on Wellesby, Grindstone and Bluff Islands use the solid ice cover as a means of transit between the mainland.

At the entrance to the St. Lawrence River at Cape Vincent, New York, commercial vessels pick up and drop off pilots that assist the ships in navigating the St. Lawrence System. However, operations cease during the winter months due to heavy ice conditions and impassible channels. Environmental baseline assessment for this stretch of the St. Lawrence River will cost approximately $1094.

Each of the four proposed COE developments for this river segment has been placed into one of two baseline update and monitoring studies. These developments and their estimated costs for baseline update and monitoring are listed below.

. Icebreaking Activities	$618
. Vessel Speed Control	1000
. Icebreaker Mooring Facilities	857
Total	$2,475

2.10.2 Alexandria through Ogdensburg

This 32 mile stretch of the St. Lawrence River from Alexandria through Ogdensburg is also currently closed from mid-December to early April due to ice cover. However, the ice is generally stable and shorefast and not subject to breakup from wind and weather conditions. Therefore, shoreline erosion and structure damage is minimal. An ice boom currently exists in the vicinity of Ogdenburg, New York, to stabilize the ice cover for power production purposes. The cost for the environmental baseline assessment of this river stretch is estimated at $1713.

Each of the proposed COE developments has been placed into one of four baseline update and monitoring studies. These developments and their estimated costs for baseline update and monitoring are listed below.

• Icebreaking Activities Vessel Speed Control	$1428
• Ice Control Structures	381
• Icebreaker Mooring Facilities	857
• Shoreline Protection	571
Total	$3237

2.10.3 Ogdensburg to Massena

The 45 mile stretch of the St. Lawrence River between Ogdensburg and Massena includes Galop Island and the Iroquois Lock and Dam maintained by Canada. Ice booms between Galop Island and the U.S.-Canadian mainland traverse the navigation channel and may impede winter navigation. The area around Ogden Island upstream of the Moses-Saunders hydroelectric plant is relatively swift flowing and has a high risk potential for ice jams.

Erosion in this section of the river is minimal, since the Power Authority of the State of New York (PASNY) owns the majority of the shoreland from the Moses-Saunders Power Dam upstream to the vicinity of the Ogdensburg bridge and their current policy prohibits year-round structures from being placed in the water along the lands that it leases. Few permanent or seasonal residences are near enough to the river to be in danger of erosion impacting them. The estimated cost for the baseline environmental assessment is $1713 for this segment of the river.

Each of the five proposed COE developments for this segment of the St. Lawrence River that will require environmental studies has been placed into one of four baseline update and monitoring studies. These developments and their estimated costs for baseline update and monitoring are listed below.

• Icebreaking Activities Vessel Speed Control	$1190
• Ice Control Structures	429
• Dredging	904
• Shoreline Protection	620
Total	$3143

Table 1.

ENVIRONMENTAL STUDY COSTS FOR LAKE SUPERIOR

(Manyears - $1000)

Harbor Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Duluth-Superior Harbor								
• Harbor Icebreaking				2 - $ 95	4 - $ 190	1 - $ 48	7 - $ 333	
• Icebreaker Mooring				2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	
• Air Bubbler Systems				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
TOTAL	8 - $ 381	3 - $ 143	11 - $ 524	6 - $ 285	22 - $1047	5 - $ 238	33 - $1570	44 - $ 2094
Ashland-Chequamenon Bay								
• Harbor Icebreaking				2 - $ 95	4 - $ 190	1 - $ 48	7 - $ 333	
• Air Bubbler Systems				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
TOTAL	8 - $ 381	2 - $ 95	10 - $ 476	4 - $ 190	12 - $ 571	3 - $ 143	19 - $ 904	29 - $ 1380
Marquette-Presque Isle								
• Icebreaker Mooring				2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	
• Air Bubbler Systems				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
TOTAL	8 - $ 381	2 - $ 95	10 - $ 476	4 - $ 190	18 - $ 857	4 - $ 190	26 - $1237	36 - $ 1713
LAKE TOTALS	24 - $1143	7 - $ 333	31 - $1476	14 - $ 665	52 - $2475	12 - $ 571	78 - $3711	109 - $ 5187

Table 2.

ENVIRONMENTAL STUDY COSTS FOR ST. MARYS RIVER

(Manyears - $1000)

River Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Whitefish Point to Locks								
• Icebreaking, Vessel Speed, Shoreline Protection				14 - $ 666	22 - $1047	6 - $ 286	42 - $1999	
• Air Bubbler Systems				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
TOTAL	20 - $ 952	5 - $ 238	25 - $1190	16 - $ 761	30 - $1428	8 - $ 381	54 - $2570	79 - $ 3760
Locks to Neebish Island								
• Icebreaking, Vessel Speed, Shoreline Protection				12 - $ 571	20 - $ 952	4 - $ 190	36 - $1713	
• Ice Boom				4 - $ 190	10 - $ 476	4 - $ 190	18 - $ 856	
• Air Bubbler Systems				4 - $ 190	10 - $ 476	4 - $ 190	18 - $ 856	
TOTAL	20 - $ 952	7 - $ 333	27 - $1235	20 - $ 951	40 - $1904	12 - $ 570	72 - $3425	99 - $ 4710
Neebish Island through Munuscong Lake								
• Icebreaking, Vessel Speed, Shoreline Protection				9 - $ 428	15 - $ 714	4 - $ 190	28 - $1332	
• Dredging				9 - $ 428	15 - $ 714	3 - $ 143	27 - $1285	
• Air Bubbler Systems				2 - $ 95	10 - $ 476	3 - $ 143	15 - $ 714	
TOTAL	20 - $ 952	6 - $ 286	26 - $1238	20 - $ 951	40 - $1904	10 - $ 476	70 - $3331	96 - $ 4569
Munuscong Lake to Detour								
• Pilot Access				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
TOTAL	4 - $ 190	1 - $ 48	5 - $ 238	2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	17 - $ 809
RIVER TOTALS	64 - $3046	19 - $ 905	83 - $3951	58 - $2758	118 - $5617	32 - $1522	208 - $9897	291 - $13848

Table 3.

ENVIRONMENTAL STUDY COSTS FOR LAKE MICHIGAN

(Manyears - $1000)

Harbor Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Green Bay-Green Bay Harbor-Escanaba								
Icebreaking, Vessel Speed, Shoreline Protection				10 - $ 476	26 - $1238	5 - $ 238	41 - $1952	
Icebreaker Mooring				4 - $ 190	10 - $ 476	2 - $ 95	16 - $ 761	
TOTAL	20 - $ 952	5 - $ 238	25 - $1190	14 - $ 666	36 - $1714	7 - $ 333	57 - $2713	82 - $ 3903
Milwaukee Harbor								
Icebreaker Mooring				2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	
TOTAL	4 - $ 190	1 - $ 48	5 - $ 238	2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	19 - $ 904
Calumet Harbors								
Air Bubbler Systems				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
TOTAL	8 - $ 381	2 - $ 95	10 - $ 476	2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	22 - $ 1047
Indiana Harbor-Burns Harbor-Gary Harbor								
Ice Control Structures				4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	
TOTAL	8 - $ 381	1 - $ 48	9 - $ 429	4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	23 - $ 1095
Muskegon-Muskegon Lake								
Icebreaking, Vessel Speed				8 - $ 381	14 - $ 666	3 - $ 143	25 - $1190	
Ice Control Structures				3 - $ 143	8 - $ 381	2 - $ 95	13 - $ 619	
TOTAL	16 - $ 762	4 - $ 190	20 - $ 952	11 - $ 524	22 - $1047	5 - $ 238	38 - $1809	58 - $ 2761
Ludington Harbor								
Icebreaking				4 - $ 190	87 - $ 381	2 - $ 95	14 - $ 666	
Ice Control Structures				2 - $ 95	4 - $ 190	1 - $ 48	7 - $ 333	
TOTAL	12 - $ 571	2 - $ 95	14 - $ 666	6 - $ 285	12 - $ 571	3 - $ 143	21 - $ 999	35 - $ 1665
LAKE TOTALS	68 - $3237	15 - $ 714	83 - $3951	39 - $1855	96 - $4570	21 - $ 999	156 - $7424	239 - $11375

Table 4.

ENVIRONMENTAL STUDY COSTS FOR LAKE HURON

(Manyears - $1000)

Harbor Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Calcite, Alpena Harbors								
• Icebreaking, Vessel Speed				7 - $ 333	16 - $ 762	5 - $ 238	22 - $1333	
• Air Bubbler Systems				4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	
TOTAL	12 - $ 571	5 - $ 238	17 - $ 809	11 - $ 523	24 - $1143	7 - $ 333	42 - $1999	59 - $ 2808
Bay City, Saginaw Bay								
• Icebreaking, Vessel Speed, Shoreline Protection				6 - $ 286	10 - $ 476	3 - $ 143	19 - $ 905	
• Ice Boom				6 - $ 286	10 - $ 476	3 - $ 143	19 - $ 905	
• Icebreaker Mooring				6 - $ 286	10 - $ 476	3 - $ 143	19 - $ 905	
TOTAL	24 - $1142	6 - $ 286	30 - $1428	18 - $ 858	30 - $1428	9 - $ 429	57 - $2715	87 - $ 4143
LAKE TOTALS	36 - $1713	11 - $ 524	47 - $2237	29 - $1381	54 - $2571	16 - $ 762	99 - $4714	146 - $ 6951

Table 5.

ENVIRONMENTAL STUDY COSTS FOR ST. CLAIR RIVER AND LAKE ST. CLAIR

(Manyears - $1000)

Harbor Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Blue Water Bridge to St. Clair Harbor								
• Icebreaking, Vessel Speed Shoreline Protection				8 - $ 381	20 - $ 952	4 - $ 190	32 - $1523	
• Compensating Works				8 - $ 381	20 - $ 952	4 - $ 190	32 - $1523	
• Ice Control Structure				5 - $ 238	8 - $ 381	3 - $ 143	16 - $ 762	
TOTAL	36 - $1714	7 - $ 333	43 - $2047	21 - $1000	48 - $2285	11 - $ 523	80 - $3808	123 - $ 5855
St. Clair Harbor to Marine City								
• Vessel Speed				5 - $ 238	10 - $ 476	2 - $ 95	17 - $ 809	
TOTAL	10 - $ 476	2 - $ 95	12 - $ 571	5 - $ 238	10 - $ 476	2 - $ 95	17 - $ 809	29 - $ 1380
Marine City to Algonac								
• Icebreaking, Vessel Speed Shoreline Protection				14 - $ 666	18 - $ 857	6 - $ 286	38 - $1809	
TOTAL	18 - $ 857	4 - $ 190	22 - $1047	14 - $ 666	18 - $ 857	6 - $ 286	38 - $1809	60 - $ 2856
Algonac to St. Clair								
• Vessel Speed, Shoreline Protection				10 - $ 476	15 - $ 714	4 - $ 190	29 - $1380	
TOTAL	15 - $ 714	3 - $ 143	18 - $ 857	10 - $ 476	15 - $ 714	4 - $ 190	29 - $1380	47 - $ 2237
RIVER TOTALS	79 - $3761	16 - $ 761	95 - $4522	50 - $2380	91 - $4332	23 - $1094	164 - $7806	259 - $12328

(Manyears - $1000)

Lake Area	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Lake St. Clair								
• Icebreaking, Vessel Speed				9 - $ 429	12 - $ 571	4 - $ 190	25 - $1190	
TOTAL	12 - $ 571	3 - $ 143	15 - $ 714	9 - $ 429	12 - $ 571	4 - $ 190	25 - $1190	40 - $ 1904
LAKE TOTALS	12 - $ 571	3 - $ 143	15 - $ 714	9 - $ 429	12 - $ 571	4 - $ 190	25 - $1190	40 - $ 1904

Table 6.

ENVIRONMENTAL STUDY COSTS FOR DETROIT RIVER

(Manyears - $1000)

River Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Peach Island to Rouge River								
• Vessel Speed, Shoreline Protection				5 - $ 238	15 - $ 714	4 - $ 190	24 - $1142	
• Icebreaker Mooring Pilot Access				3 - $ 143	10 - $ 476	3 - $ 143	16 - $ 762	
• Ice Control Structures				2 - $ 95	8 - $ 381	2 - $ 95	12 - $ 571	
• Compensating Works				5 - $ 238	15 - $ 714	4 - $ 190	24 - $1142	
TOTAL	36 - $1714	8 - $ 381	44 - $2095	15 - $ 714	48 - $2285	13 - $ 618	76 - $3617	120 - $ 5712
Rouge River to Trenton								
• Vessel Speed, Shoreline Protection				10 - $ 476	15 - $ 714	4 - $ 190	29 - $1380	
TOTAL	15 - $ 714	4 - $ 143	18 - $ 857	10 - $ 476	15 - $ 714	4 - $ 190	29 - $1380	47 - $ 2237
Trenton to Pt. Mouillee								
• Icebreaking, Vessel Speed, Shoreline Protection				14 - $ 666	18 - $ 857	6 - $ 286	38 - $1809	
TOTAL	18 - $ 857	4 - $ 190	22 - $1047	14 - $ 666	18 - $ 857	6 - $ 286	38 - $1809	60 - $ 2856
RIVER TOTALS	69 - $3285	15 - $ 714	84 - $3999	39 - $1856	81 - $3856	23 - $1094	143 - $6806	227 - $10805

Table 7.

ENVIRONMENTAL STUDY COSTS FOR LAKE ERIE
(Manyears - $1000)

Harbor Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Lake Erie (West Basin)								
Icebreaking				4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	
TOTAL	8 - $ 381	1 - $ 48	9 - $ 429	4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	23 - $ 1095
Monroe-Toledo Harbors								
Icebreaking				3 - $ 143	10 - $ 476	2 - $ 95	15 - $ 714	
Icebreaker Mooring				3 - $ 143	8 - $ 381	2 - $ 95	13 - $ 619	
Air Bubbler Systems				2 - $ 95	4 - $ 190	2 - $ 95	8 - $ 380	
TOTAL	12 - $ 571	4 - $ 190	16 - $ 761	8 - $ 381	22 - $1047	6 - $ 285	36 - $1713	52 - $ 2474
Sandusky Bay, Sandusky, Huron, Lorain Harbors								
Icebreaking, Vessel Speed				9 - $ 429	16 - $ 762	3 - $ 143	28 - $1334	
Ice Control Structures				5 - $ 238	12 - $ 571	4 - $ 190	21 - $ 999	
Air Bubbler Systems				5 - $ 238	12 - $ 571	4 - $ 190	21 - $ 999	
TOTAL	30 - $1428	7 - $ 333	37 - $1761	19 - $ 905	40 - $1904	11 - $ 523	70 - $3332	107 - $ 5093
Cleveland Harbor								
Icebreaker Mooring				4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	
Ice Control Structures				2 - $ 95	6 - $ 286	2 - $ 95	10 - $ 476	
TOTAL	10 - $ 476	2 - $ 95	12 - $ 571	6 - $ 285	14 - $ 667	4 - $ 190	24 - $1142	36 - $ 1713
Ashtabula, Conneant Harbors								
Ice Control (Ashtabula)				4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	
Ice Control (Conneant)				4 - $ 190	8 - $ 381	2 - $ 95	14 - $ 666	
TOTAL	16 - $ 762	2 - $ 95	18 - $ 857	8 - $ 380	16 - $ 762	4 - $ 190	28 - $1332	46 - $ 2189
Buffalo Harbor								
Icebreaking				2 - $ 95	4 - $ 190	1 - $ 48	7 - $ 333	
Icebreaker Mooring				6 - $ 286	10 - $ 476	2 - $ 95	18 - $ 857	
TOTAL	4 - $ 190	1 - $ 48	5 - $ 238	8 - $ 381	14 - $ 666	3 - $ 143	25 - $1190	30 - $ 1428
LAKE TOTALS	80 - $3808	17 - $ 809	97 - $4617	53 - $2522	114 - $5427	30 - $1426	197 - $9375	294 - $13992

Table 8.

ENVIRONMENTAL STUDY COSTS FOR LAKE ONTARIO

(Manyears - $1000)

Harbor Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Oswego								
Icebreaker Mooring				2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	
TOTAL	4 - $ 190	1 - $ 48	5 - $ 238	2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	19 - $ 904
Cape Vincent								
Icebreaker Mooring				2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	
Pilot Access								
TOTAL	4 - $ 190	1 - $ 48	5 - $ 238	2 - $ 95	10 - $ 476	2 - $ 95	14 - $ 666	19 - $ 904
LAKE TOTALS	8 - $ 380	2 - $ 96	10 - $ 476	4 - $ 190	20 - $ 952	4 - $ 190	28 - $1332	38 - $ 1808

Table 9.

ENVIRONMENTAL STUDY COSTS FOR ST. LAWRENCE RIVER

(Manyears - $1000)

River Areas	Baseline	Evaluation	Total	Update	Monitoring	Validation	Project Total	Area Total
Cape Vincent to Alexandria								
Icebreaking				4 - $ 190	7 - $ 333	2 - $ 95	13 - $ 618	
Vessel Speed, Shoreline Protection				6 - $ 286	13 - $ 619	2 - $ 95	12 - $1000	
Icebreaker Mooring				6 - $ 286	10 - $ 476	2 - $ 95	18 - $ 857	
TOTAL	20 - $ 952	3 - $ 142	23 - $1094	16 - $ 752	30 - $1428	6 - $ 285	52 - $2475	75 - $3569
Alexandria through Ogdensburg								
Icebreaking, Vessel Speed				8 - $ 381	18 - $ 857	4 - $ 190	30 - $1428	
Icebreaker Mooring				6 - $ 286	10 - $ 476	2 - $ 95	18 - $ 857	
Shoreline Protection				4 - $ 190	7 - $ 333	1 - $ 48	12 - $ 571	
Ice Control Structures				2 - $ 95	5 - $ 238	1 - $ 48	8 - $ 381	
TOTAL	32 - $1523	4 - $ 190	36 - $1713	20 - $ 952	40 - $1904	8 - $ 381	68 - $3237	104 - $ 4950
Ogdensburg to Massena								
Icebreaking, Vessel Speed				6 - $ 286	15 - $ 714	4 - $ 190	25 - $1190	
Shoreline Protection				3 - $ 143	9 - $ 429	1 - $ 48	13 - $ 620	
Dredging				5 - $ 238	12 - $ 571	2 - $ 95	19 - $ 904	
Ice Control Struct				2 - $ 95	6 - $ 286	1 - $ 48	9 - $ 429	
TOTAL	32 - $1523	4 - $ 190	36 - $1713	16 - $ 762	42 - $2000	8 - $ 381	66 - $3143	102 - $ 4856
RIVER TOTALS	84 - $3998	11 - $ 522	95 - $4520	52 - $2476	112 - $5332	22 - $1047	186 - $8855	281 - $13375

ATTACHMENT C TO APPENDIX E

TYPICAL ENVIRONMENTAL STUDIES

CONTENTS

CONTENTS (Continued)

INTRODUCTION TO TYPICAL ENVIRONMENTAL STUDIES

(ATTACHMENT C)

The environmental studies herein described were developed to accommodate the various engineering developments considered necessary for extended navigation. Some studies are redundant and would be combined by geographic area in the event that authorization and funding are available. This redundancy was recognized when the studies were developed and was discussed at the series of public meetings held in May of 1979. The appearance of redundancy was necessary to show what should be studied for each type of activity and to comply with the intent of NEPA. These studies also were developed in this manner for the fiscal budgetary process in estimating the total cost of the project.

A. LAKES, CONNECTING CHANNELS AND ST. LAWRENCE RIVER

OPERATIONAL MEASURE #1 - ICEBREAKING REQUIREMENTS

This activity includes icebreaking with ships of several sizes. The existing ships include: 2 type "B" icebreakers - the "Mackinaw" built especially for the Great Lakes with a 290-foot length and a 20-foot draft, and the polar class "Westwind" with a working draft of 25 feet; five 180-foot buoy tenders with a 14-foot draft; and 5 type "C" harbor tugs with a 110-foot length and an 11-foot draft. The harbor tugs and buoy tenders would be replaced by ten 140-foot long vessels with a 14-foot draft, with more icebreaking capability. The preliminary estimates for additional icebreaking requirements include an additional 4 type "B" and 20 type "C" icebreakers. These vessels would be positioned in strategic points throughout the system.

Environmental Concerns

Icebreaking activity in the shallow parts of the system, especially in the connecting channels, could cause adverse effects on the environment. The propeller wash generated by the deep draft type "B" icebreakers causes powerful currents which could stir up bottom sediments in the dredged channels and shallow adjacent areas. This material varies in particle size so that it settles out at varying distances. The heavier particles probably do not leave the navigation channels; whereas, the lighter flocculent material may be transported long distances downstream. Thus, the two predominant effects are sedimentation and turbidity. In contaminated, shallow water areas of the system, heavy metals, PCB's and other polluting toxicants could be resuspended with resulting adverse environment effects. In addition, the propeller wash could push broken ice under the ice cover on each side of the track. This ice could subsequently freeze, accumulate, and form an ice rampart or underwater ridge on both sides of the track. These underwater ridges could alter existing localized water currents and circulation patterns. The broken vessel track also could prohibit or alter animal movement patterns. The exact nature and extent of these effects are not presently known and would be determined through appropriate studies.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Water quality - turbidity, heavy metals, PCB's and other toxicants

2. Sediment transport - in channel and out channel

3. Water current patterns and velocities - with and without ramparts

B. Biological

1. Fish use of navigation channel

2. Fish population dynamics

3. Fish migration and spawning patterns

4. Benthic population dynamics - in and outside of the channel

5. Terrestrial animal use of waterway (movement)

6. Aquatic vegetation - species composition, density and location

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort * (Man-Years)	Cost
Inventory	8	$ 380,800
Appraisal	1	47,600
Base Condition Update	4	190,400
Monitoring	8	380,800
Evaluation	2	95,200
Totals	23	$1,094,800

Location and Number of Studies

These studies should be located in the dredged navigation channels, and the selection sites would be based on existing bottom types and sediments. Most dredged areas are in the connecting channels, and it is estimated that there would be two studies in the St. Marys River, one in Whitefish Bay, two in the St. Clair River, one in Lake St. Clair, one in the Detroit River, and three in the St. Lawrence River. This is a total of 10 study site locations.

Timetable of Studies

Much of the base conditions inventory has been acquired but is not completed. Studies should be initiated to allow completion of the base condition inventory prior to finalizing the Phase I GDM. The base condition update studies should be started at least two years before icebreaking begins, and the level of effort would be 50 percent of the original study costs.

Contingencies

In the event damages to the environment are observed from icebreaking activities in some of the more environmentally important harbors and harbor entrances, or in the shallow west basin of Lake Erie, monitoring studies also would be implemented at those points. The system-wide studies (i.e., Section C) would take into consideration cumulative impacts.

OPERATIONAL MEASURE #2 - ICEBREAKER MOORING FACILITIES

This activity would include mooring facilities at a maximum of 13 harbors. The typical developments needed at these sites each encompass about 4 acres of land acquisition for shore facilities and storage, as well as dredged access channels of varying lengths, widths and depths, and pier facilities. Water sewage, electrical, telephone and fuel handling facilities would be included. Mooring facilities are being considered at the following locations:

Type B icebreakers

1. Duluth - Superior - Minnesota - Wisconsin - Lake Superior
2. Sault Ste. Marie, Michigan - Lake Superior
3. Detroit, Michigan - Detroit River
4. Cleveland, Ohio - Lake Erie

Type C icebreakers

1. Sault Ste. Marie, Michigan - Lake Superior
2. Escanaba, Michigan - Lake Michigan
3. St. Ignace, Michigan - Lake Huron
4. Port Huron
5. Detroit, Michigan - Detroit River
6. Toledo, Ohio - Lake Erie
7. Cleveland, Ohio - Lake Erie
8. Buffalo, New York - Lake Erie
9. Oswego, New York - Lake Ontario
10. Cape Vincent, New York - Lake Ontario and St. Lawrence River
11. Alexandria Bay, New York - St. Lawrence River
12. Ogdensburg, New York - St. Lawrence River

Environmental Concerns

The environmental damages associated with these developments are dependent upon site location (e.g., if located adjacent to existing wetlands, severe damages could occur). Some of the above listed wetlands, severe damages could occur). Some of the above listed harbors have known or suspected fish spawning sites which may contain overwintering eggs. The resulting propeller wash of the icebreakers and other vessels could cause severe loss of eggs. Many of the harbors have polluted bottoms, and dredging access channels could resuspend these pollutants. Dredged material placement also is of concern.

Environmental studies and assessments on each specific site for icebreaker mooring facilities would be ncessary to determine impacts and evaluate alternatives to mitigate or eliminate damages. Appropriate studies would be developed for each proposed mooring facility to determine the environmentally acceptable site location.

Environmental Studies

I. Resource Inventory (Base Condition)

  A. Physical

    1. Water quality - turbidity, heavy metals, sedimentation, etc.

    2. Sediment quality

    3. Sediment transport

    4. Water current patterns and veolcities

    5. Land use at facility site

  B. Biological

    1. Waterfowl usage

    2. Fish usage

      (a) Population dynamics
      (b) Migration and spawning

    3. Vegetation study (aquatic and terrestrial)

    4. Benthic study (access channel area)

    5. Wildlife population and dynamics - where applicable

II. Appraisal - The information gathered on base conditions would be evaluated and would form the basis for the site assessment and the determination of best alternative.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage would be accomplished at the selected mooring sites. Studies would gather data during the construction and operation phases to make comparisons and a determination as the nature and extent of the effects.

V. Evaluation Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project-induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Reports would be submitted to the Corps for the appropriate action.

Type of Study	Level of Effort (Man-Years)	Cost
Inventory	4	$ 190,400
Appraisal	1	47,600
Base Condition Update	2	95,200
Monitoring	10	476,000
Evaluation	2	95,200
Totals	19	$ 904,400

Location and Number of Studies

These studies would be located at all sites where land acquisition and dredged access channels are being considered. It is estimated that about 13 of the sites would need to be studied. A two to three member team could conduct studies at more than one site. Some of the sites would have facilities for both type "B" and "C" icebreakers.

Timetable of Studies

The base condition inventory would have to be initiated at least three years before completion of the Phase I GDM to allow time to acquire the data, make an appraisal, and allow time to make a decision among the alternatives prior to submission of an EIS. The monitoring would take place during construction and during operation. There could be a lapse between the intensive base condition inventory study and the monitoring. The base condition data would be updated with an effort estimated to be 50 percent of the original collection costs. This would be a two-year study effort immediately preceding construction.

Contingencies

In the event that additional mooring sites would be necessary, the sites would be coordinated with the U.S. Fish and Wildlife Service and other appropriate agencies early in the planning process so that the necessary studies could be conducted. The funding for the studies would be a responsibility of the implementating Federal agency.

OPERATIONAL MEASURE #3 - VESSEL TRAFFIC CONTROL

The three main sections of this activity are as follows:

1. Traffic control to prevent collisions, ramming, and groundings includes 2-way traffic in Middle Neebish Channel, closed circuit TV at two points in the Channel and associated control equipment (e.g., some type of enclosure), a traffic control center, and two remote transmitting UHF-FM communication facilities.

2. Traffic control for voyage includes automatic emergency position radio beacons on the ships.

3. Traffic control for icebreaking and vessel convoying includes an automated reporting system.

This development would aid in reducing environmental damages, shore erosion and shore structure damages by reducing the speeds within convoys while under the control of the traffic control operators.

Since it is anticipated that the environmental impacts would be minimal, base condition and monitoring studies do not appear necessary for this development. However, care should be taken in locating the closed circuit TV installations and the cable, etc., at the two sites. The U.S. Fish and Wildlife Service would provide assistance in site selection.

OPERATIONAL MEASURE #4 - ICE DATA COLLECTION/DISSEMINATION SYSTEMS

This includes the Ice Navigation Center located in Cleveland, Ohio, and the necessary staff to maintain a 24-hour, 7-day per week operation during an extended navigation season, as well as expanded physical facilities and new equipment. Significant adverse environmental impacts are not anticipated with planned activities, and environmental studies do not appear necessary.

OPERATIONAL MEASURE #5 - ICE AND WEATHER FORECASTS

This activity would improve the ability to forecast ice and weather conditions from the Ice Information Center. No significant adverse environmental impacts are anticipated, and environmental studies do not appear necessary.

OPERATIONAL MEASURE #6 - AIDS TO NAVIGATION

All-weather aids to navigation are necessary to determine ship position and assist vessels in safely transiting the system. The principle aid is the mini-LORAN-C electronic system, which precisely fixes a ship's position. Lighted channel markers with radar transponders (RACONS) and course range markers also are used as aids to properly orient the ships in the channels. Normally, the channel markers are removed during the winter to prevent loss. Additionally, needed winter structures would be of several types, including metal tripods, caissons with lights, and pile clusters. The course ranges would consist of lighted and painted towers, usually on land, to direct ships on specific courses. Extended season navigation would need the following aids to navigation:

Duluth - Superior Harbor - 6 fixed lighted structures

Birch/Brush and Big Points - 1 lighted structure each

St. Marys River - 8 lighted structures

Green Bay - 4 lighted structures

Alpena Harbor - 1 lighted structure

Saginaw Bay - 2 lighted structures

Lake Huron Cut - 1 lighted structure

Detroit River- East Outer Channel - 1 lighted structure

Toledo - 1 lighted structure

St. Lawrence River - 12 lighted structures, 2 course ranges, 19 radar reflectors

Environmental Concerns

The installation of these structures would result in localized adverse environmental effects. The location and type of structure have a significant bearing on environmental effects. The area for course ranges would have to be cleared from the water's edge to the rear range light, and this could adversely impact terrestrial habitats. The aquatic habitats also could be adversely affected by the caisson type of structure. By placing these structures at the channel edge, damages would be minimized. Although studies do not appear to be necessary, the U.S. Fish and Wildlife Service would participate in the planning for these structures so that environmental damages could be minimized or eliminated.

OPERATIONAL MEASURE #7 - ICE CONTROL STRUCTURES

This activity includes ice booms and ice stabilization islands in the connecting channels and the St. Lawrence River. In the St. Marys River, the project proposal is to redesign and reinstall the demonstration ice booms at the head of Sugar Island, construct two rubblemound ice stabilization islands in the lower part of Sault Ste. Marie Harbor, and relocate the city's sewer outfall from the harbors to the Little Rapids area. The ice booms would have a 250-foot navigation gap, and the sewage outfall would be relocated at a point just upstream from the mainland Sugar Island ferry dock. This would allow the upstream harbor ice to stabilize by forming shorefast ice.

Ice booms also are proposed in the St. Clair-Detroit Rivers connecting channels. These ice booms would be across the St. Clair River, about one mile upstream from the Bluewater Bridge near Port Huron, and in the Detroit River where it flows from Lake St. Clair. The purpose is to stabilize the natural ice bridge upstream in Lakes Huron and St. Clair so that ice jams do not continue to occur in downstream river areas.

The ice booms in the St. Lawrence River are proposed to be increased in number and modified. Ice booms have been installed by the power companies annually for a number of years to minimize ice jams upstream from hydroelectric power plants. These booms would be modified to allow vessel passage and would include 250-foot openings in the main heavy-duty ice booms with 1,000-foot wing booms adjacent and parallel to the navigation channel on the upstream side. In addition, light-duty booms would be interspersed upstream from the main booms to stabilize the ice.

Three different types of anchors could be utilized to hold the ice booms in place. The mud anchor would be used for soft bottom areas, the imbedded chain type for hard bottom areas, and the H-Pile types for moderately firm bottom areas. The mud anchor is dredged into place, the H-Pile type is driven into the bottom, whereas, the imbedded chain type is constructed by drilling a hole into the bottom and imbedding the chain in concrete within the hold.

Environmental Concerns

These activities could cause significant adverse environmental effects. Water levels and flows would be affected by the structures and by the friction caused by the stabilized ice fields. This effect could have adverse impacts on fish and wildlife resources if flooding and/or dewatering would occur. Dredging of the mud anchors would disrupt aquatic habitat. However, the magnitude of the disruption would be dependent upon the number of anchors used. Additionally, the sewage outfall relocation could adversely affect fish and wildlife by providing warm polluted water in a different location. The stabilization of the ice and ice booms could enhance ice fishing in those areas because of the increased safety provided. Studies would be made to determine the extent of these effects. Effects of the changes in levels and flows could extend beyond the site; therefore, system-wide studies on the ramifications of changes in levels and flows would be done.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Water levels and flows would be monitored to a greater level than now exists -- proposals are adequate

2. Current pattern changes would be necessary to determine impacts in the environment. Changes on the St. Clair and Detroit Rivers could be studied in conjunction with proposed compensating works

3. Water quality - turbidity, in conjunction with current pattern changes and outfall relocation

4. Sediment and bottom types - anchors and current pattern changes

5. Definition of shoreline - map and measure water line differences

B. Biological

1. Benthic studies - population dynamics by bottom type

2. Wetland inventory

3. Fish - population dynamics

4. Winter water fluctuations - environmental effects

5. Fishing use inventory

6. Waterfowl - open water area below booms

7. Furbearer and mammal use of area

II. Appraisal - The acquired information would be evaluated and would form the basis for the assessment.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data in the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriated, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriation.

Type of Study	Level of Effort (Man-Years)	Cost
Inventory	4	$ 190,400
Appraisal	1	47,600
Base Condition Update	2	95,200
Monitoring	10	476,000
Evaluation	2	95,200
Totals	19	$ 904,400

Contingencies

In the event base condition inventories and the subsequent appraisals show that further studies are needed, there would be recommended in the first appraisal report.

OPERATIONAL MEASURE #8 - AIR BUBBLER SYSTEMS

This activity would be located in the St. Marys River at a number of tight turns where ships operating in the ice have difficulty. These turns are located as follows: (1) Whitefish Bay - Birds Point Turn; (2) Middle Neebish Channel - turn between Course 5 & 6; (3) Middle Neebish Channel - turn between Course 6 & 7; (4) Middle Neebish Channel - turn between Courses 7 & 8 and 8 & 9; and, (5) Lime Island Turn.

A typical facility includes an anchored bubbler pipe varying in length and diameter with small orifices to emit air, a pipe leading from the compressor, a diesel powered compressor with coolers, dryers and a standby compressor, and a prefabricated metal building to house the compressors. The length of the bubblers would be 3,500 feet at turns between Course 7 & 8 and 8 & 9; 5,000 feet at turns between 5 & 6, 6 & 7 and Lime Island turn; and 10,000 feet at the Birds Point Turn. These would be deisgned to emit air bubbles at a pressure of 10 to 15 pounds per square inch. The bubblers would be operated constantly all winter and would be placed so that a relief zone would be provided for the ships to make the turn. The anchors of the pipe would be concrete blocks spaced at about 10-foot intervals. The diffuser pipe, attached to these anchors with nylon rope, would have orifices spaced about 10 feet apart.

Environmental Concerns

The bubblers could have both adverse and beneficial effects. The bubblers, when operated constantly, probably would create an area of open water. The orifices have been spaced closely (10 feet apart) and the inverted cone of bubbles probably would merge to form a bubble curtain at the upper levels.

The open water areas could attract waterfowl. If the food supply at the site is limited and the terrestrial food supply is covered with snow, the waterfowl could become too weak to leave the area and, thus, eventually die from complications associated with malnutrition. Since these bubblers would be in a flowing water situation, the effect of using up the heat sink would not be applicable. If this were the case, the lower water temperature would have an effect on the aquatic fauna in the area. However, the extent of effects is not known and studies would be necessary to determine the extent of effects. Some concern has been expressed that the vertical water currents generated by the bubblers could resuspend polluted sediments. However, the described bubblers would be located in unpolluted areas and operated at low enough air pressures to prevent sediment resuspension.

Bubblers may have a certain amount of beneficial effects. The bubblers may have an oxygenating effect on the waters as they move through the area. This may be a local effect and may not be sufficient to sustain fish and other aquatic fauna of the area. However, fish and other mobile animals may be attracted to the area, and these effects also should be studied.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Water quality - background, oxygen content, etc.

2. Hydrology of stream segment

3. Changes in embayment, basins, and systems heat budgets

B. Biological

1. Waterfowl use (year-round)

2. Fish - population dynamics (species composition and winter use of area)

3. Benthos

4. Plankton (open water in winter)

II. Evaluation - The acquired data would be evaluated and used as a basis for the assessment and EIS. The evaluation would be based on the concerns expressed and whether the data would be useful in a comparison of with and without the project conditions.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data in the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Report would be submitted to the Corps for implementation.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	4	$ 190,400
Appraisal	1	47,600
Base Condition Update	2	95,200
Monitoring	10	476,000
Evaluation	2	95,200
Totals	19	$ 904,400

Location and Number of Studies

This activity would include seven sites in the St. Marys River. It would be feasible for the whole bubbler study, including monitoring aspects, to be handled by a single two-member crew.

Timetables of Studies

The base condition inventory would be of two years duration during Phase I GDM. A 2- to 5- year time lapse or even longer could occur between the base condition inventory and the monitoring effect. During this period, data would be acquired on selected parameters so that the inventory would be kept current. The appraisal would determine which parameters to continue with data collection. After the intensive acquisition of base condition inventory data, the data would be evaluated and used for the environmental assessment and EIS preparation. The base condition data would be updated with an effort equal to 50 percent of the original study costs. This is a two-year study effort immediately preceding construction.

The next step would be the monitoring of the effects of the activities during operation on the environment. This may or may not include all the items studied in the baseline depending on the results of the evaluation of initial baseline data.

The last evaluation would compare the data to the base conditions to determine the effects of the activities. A report would be written which would include, as appropriate, recommendations to mitigate or eliminate adverse effects.

Contingencies

There also is the possibility that additional adverse effects would be observed during the monitoring studies. In that event, additional studies with appropriate funding would be required to document these effects.

OPERATIONAL MEASURE #9 - LOCK MODIFICATION

This activity at the Soo Locks includes surfacing of the lock walls with a copolymer coating and removing adhering ice with steam hoses and butterfly valves, a tug to remove ice from the upper part of the lock chamber, a bubbler-flusher to remove ice from gate recesses, and heating cables on the machinery for the gates. Ice would be directed through the unused lock at the Soo and into unused areas below the locks. Although bottom scouring occurs year-round, it would be accelerated in the locks and approaches. Winter operation would require refitting of existing floating equipment and acquiring one icebreaking 65-foot tug with 1,600 horsepower.

The developments at the locks on the St. Lawrence would include installing heating coils in the lock walls, heating the mating edges of the gates, replacing the upper gates with sector gates containing heating coils, flow developers in the lock walls and approach walls, and constructing a diversion channel around the locks with an ice crusher and flow control weir. Heated inclosures for machinery and personnel also would be constructed. A small tug would be needed, and the existing icebreaking tug would need to be refitted with new propellors and with air lubrication for the hull.

The adverse environmental effects of these developments would be minimal and confined essentially to structure areas. The bottom scour from the operations of the shallow draft tugs would be insignificant and studies do not appear necessary. However, the U.S. Fish and Wildlife Service would participate in the planning for the structural changes so that environmental damages could be minimized or eliminated.

OPERATIONAL MEASURE #10 - POWER PLANT PROTECTION

This activity includes preventing ice jams in upstream intake and downstream outlet areas at other power plants on the St. Marys, St. Clair, Detroit and St. Lawrence Rivers.

The measures proposed to prevent ice jams could cause significant environmental impacts, and these potential impacts and projected necessary studies are addressed under the section titled "Operational Measure #7 - Ice Control Structures".

OPERATIONAL MEASURE #11 - DREDGING

This activity would take place in two locations: the Middle Neebish Channel reach of the St. Marys River and the St. Lawrence River between Iroquis Dam and Ogden Island for the 11-month navigation season. The dredging on the St. Lawrence would not be necessary for a 10-month season.

In the St. Marys River, summer vessel traffic uses two existing routes around Neebish Island, the west Neebish and Middle Neebish Channels. Dredging is not planned for the West Neebish channel whereas the Middle Neebish Channel would be expanded to the authorized width. Presently the Middle Neebish Channel is only 300 feet wide at the current authorized 28-foot depth. The plan would be to widen the existing channel to a 700-foot bottom width which would require the removal of approximately 3 million cubic yards of materials. Several alternatives or combinations of alternatives for dredged material disposal have been explored. The recommended plan would be to barge the dredged materials to Lake Huron and dispose of the materials in waters of at least a 150-foot depth. Although upland disposal sites are continually being explored, suitable sites have not been identified to date.

Dredging of the St. Lawrence River for the 11-month season would occur in the reach between the Iroquis Dam and the lower end of Ogden Island. No dredging is proposed if a ten month season is proposed. This reach presently has current velocities too fast for stable ice to form, thus brash ice forms, flows downstream and blocks power plant intake structures. Certain areas within this reach would be dredged to reduce present current velocities of 2.6 to 2.9 feet per second to below 2.25 feet per second, thus allowing stable ice to form. Additional ice booms would be installed to incure a stable ice cover. Channel excavation would result in the removal of an estimated 25.2 million cubic yards of materials. Present plans indicate that Ogden Island would be used as the disposal site for the excavated materials.

The ice formation would not have progressed far enough to warrant dredging to reduce current velocities in the proposal for a 10-month season. The St. Lawrence would be closed during February and March.

Environmental Concerns

Dredging disturbs and disrupts bottom habitat for fish and bottom dwelling organisms, and temporarily increases downstream turbidity. Dredging also changes current patterns and velocities in a project and related upstream and downstream areas. When a navigation channel is constantly redredged, as would be the case in the Middle Neebish Channel of the St. Marys River, the disruption and disturbance of bottom habitat could result in severe adverse environmental impacts.

In the St. Lawrence River, the same basic concerns are evident as in the Middle Neebish Channel of the St. Marys River. However, the nature of the dredging in the St. Lawrence River is such that the proposed navigation channel would only occupy about one-third of the excavated area. Accordingly, excessive amounts of high-quality habitat would be severely altered and existing current patterns would be drastically changed.

Disposal of the estimated 3 and 25.2 million cubic yards of materials excavated from the St. Marys and St. Lawrence Rivers, respectively, also presents environmental concerns of a great magnitude. Dredged materials placed on upland or in aquatic areas drastically reduce habitat values until the materials revegetate or are rehabilitated by other processes. In many instances, disposal areas do not revegetate or rehabilitate for long periods of time, especially if materials are periodically placed on or within the same areas. In some isolated instances, dredged materials cannot be rehabilitated and valuable habitat is permanently destroyed. Thus, rehabilitation and revegetation also are dependent upon the type of disposal materials.

Dredge disposal operations in aquatic areas could be equally beneficial to fish and wildlife, such as the placement of materials to form spawning reefs, ice stabilization islands and riprap to abate erosion. However, these uses should be studied in sufficient detail to determine functional and beneficial uses prior to implementation. Dredged materials placed on upland sites usually can be rehabilitated faster by implementing certain practices (e.g., replacing top soil and planting the area with suitable wildlife vegetation). To date, however, disposal of dredged materials in both upland and aquatic areas has been inordinately damaging to fish and wildlife resources since in many instances this activity has not been adequately planned and coordinated.

Dredging in the St. Marys and St. Lawrence Rivers also could lower water levels in the immediate project vicinity and in upstream and downstream areas. This could subsequently reduce the amount of wetlands available for fish and wildlife resources. (The Corps is including an analysis of this problem in the Survey Report as well as costs for related compensating works.)

The level of knowledge about environmental impacts of dredging would allow certain measures to be recommended to minimize or eliminate some adverse effects before studies on other less understood impacts are initiated. The same is true about the placement of dredged materials, and such measures should be incorporated into the recommended plan.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Water quality - selected parameters

2. Sediment quality - bottom type, particle size, pollutant types and concentrations, etc.

3. Sediment transport

4. Disposal sites - location, habitat type and habitat quality

5. Hydrology - current patterns, water flows and water levels

B. Biological

1. Fish - population dynamics (both resident and migrating species)

2. Benthos - population dynamics

3. Disposal sites - fish and wildlife use and value

4. Aquatic vegetation - species composition, density and location

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

		Level of Effort (Man-Years)	Costs
St. Marys -	Inventory	8	$ 380,800
	Appraisal	1	47,600
	Base Condition Update	4	190,400
	Monitoring	8	380,800
	Evaluation	2	95,200
	Subtotals	23	$1,094,800
St. Lawrence* -	Inventory	8	$ 380,800
	Appraisal	1	47,600
	Base Condition Update	4	190,400
	Monitoring	10	476,000
	Evaluation	2	95,200
	Subtotals	25	$1,190,800
	GRAND TOTALS (SAY)		$2,285,600

*Dredging proposed for the 11-month navigation season

Location of Studies

Environment studies of the Middle Neebish Channel reach of the St. Marys River and the Iroquois Dam to Odgen Island reach of the St. Lawrence River would be initiated independently. These studies would be inclusive of all proposed dredge and dredge disposal sites.

Timetable of Studies

Studies of the proposed dredge areas would be implemented to allow completion of the base condition inventory prior to finalization of the Phase I GDM. The base condition update studies would be initiated at least two years prior to construction at a level of effort of approximately 50 percent of original study costs. Fish and

wildlife resource values that would be distributed or destroyed would be determined so that appropriate alternatives, including no construction, could be implemented. Disposal site studies also would be implemented in a similar manner to determine acceptable sites. If dredging is implemented at the conclusion of the studies, monitoring would be initiated to determine and document actual fish and wildlife losses from dredging and dredge material placement, and a report would be submitted to the Corps recommending means to mitigate or compensate adverse environmental effects.

Contingencies

In the event that unforeseen environmental losses are encountered during construction, provisions should be made to halt construction and implement an environmentally acceptable alternative course of action. However, if an acceptable alternative could not be implemented, construction should be halted.

OPERATIONAL MEASURE #12 - COMPENSATING WORKS

This activity is proposed to compensate for the difference in levels and flows due to ice boom placement and ice stabilization in the St. Clair and Detroit Rivers. The objective of these training wall and flow control gate structures is to partially control the flows of the rivers (the structures would not extend across the river). These proposed structures would be placed in the vicinity of Stag and Peach Islands. The training walls would be dike-like with granular cores (random rockfill with a riprap covering). The gated portion would be equipped with buoyant flap gates set into a concrete supporting structure with sheet pile and concrete cells at the ends. The top of the structures would be about 9 feet above the main low water datum. The operation of these structures would be based on historic monthly average flow.

Environmental Concerns

The areas where these works would be constructed are believed to be utilized as feeding and spawning habitat by a variety of important fish species. One such species that may utilize the Peach Island upstream shoal as a spawning site is the Lake Sturgeon, a species with relatively low populations that could be designated as a rare or endangered species in the future.

The purpose of these works is to compensate for anticipated increased downstream flows due to ice stabilization in Lakes Huron and St. Clair. However, if the flows are overly stabilized, wetlands in both upstream and downstream reaches could be severely degraded. These wetland areas are highly dependent upon cyclic eater level fluctuations to remain viable and dynamic. Accordingly, water level fluctuations and fluctuation cycles must be maintained in a manner similar to natural occurrences.

Another potential adverse environment impact associated with the construction and operation of these works is the change in current patterns in stream reaches. In certain portions of St. Clair-Detroit Rivers, the bottoms are excessively polluted. If current patterns significantly change, polluted materials could be resuspended and adversely affect valuable fish and wildlife resources in downstream areas. In addition, changed current patterns could seriously degrade or destroy important feeding and spawning areas, spawn, and bottom dwelling food organisms.

Accordingly, studies would be initiated to determine if the beneficial effects of controlling water levels, flows, and fluctuations in the lower part of the system outweigh the adverse environmental effects of the construction and operation.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical (site and downstream)

1. Hydrology - water velocities, currents, levels and flows

2. Sediment quality - bottom type, particle size, pollutant and concentrations

3. Sediment Transport

4. Water current patterns - with and without compensating works

5. Water levels - fluctuations and cycles

B. Biological

1. Fish - population dynamics, current habitat, use, and value

2. Benthic - population dynamics, current habitat, use, and value

3. Waterfowl - population dynamics, current habitat, use, and value

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/ or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriate recommendations would be formulated to eliminate, mitigate or compendate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	10	$ 476,000
Appraisal	2	95,200
Base Condition Update	5	238,000
Monitoring	15	714,000
Evaluation	3	142,800
Totals	35	$1,666,000

Location and Number of Studies

These studies should be located in the vicinity of the two compensating work sites at varying distances upstream and downstream from the compensating features. Much of these studies could be conducted in conjunction with other studies.

Timetable of Studies

Certain parameters of the base condition inventory (i.e., water level and flow studies) should be initiated at least three years prior to preparation of the EIS to measure an adequate data base. Studies on the remaining parameters would be of a 2-year duration and also should be concluded prior to EIS preparation. Base condition updates, at a level of effort of 50 percent, would be conducted on selected parameters during the 2-year period of time immediately preceding construction. Construction would probably span over a period of 3 to 4 years at each site. Accordingly, monitoring studies should be initiated to coincide with construction activities and continue for a period of at least 4 years following construction completion to adequately document project induced changes. If appropriate, recommendations would be presented to the Corps to eliminate, mitigate or compensate adverse environmental effects.

Contingencies

In the event unforeseen damages are observed, provision for additional studies should be made. If inordinate damages are observed or if it is determined that unacceptable environmental damages would occur, construction or operational activities should be halted until an acceptable alternative course of action is determined.

OPERATIONAL MEASURE # 13 - SHORELINE AND SHORE STRUCTURE PROTECTION

This activity is essentially a study to determine the areas that would be susceptible to erosion and structural damage from extended winter navigation, as well as from other causes, and the most acceptable means to correct such adverse effects. Preliminary estimates of shoreline lengths that appear particularly susceptible are: 4.8 miles on the St. Marys River; 0.75 miles on the St. Clair River; 0.77 miles on the Detroit River; and 3.2 miles on the St. Lawrence River.

The range of alternative means to prevent damages or to provide protection for the shoreline or shore structures that have been proposed includes: (1) vessel speed regulation; (2) vessel route regulation; (3) vessel movement regulation through unstable ice; (4) Department of the Army permit language modification for shore structures;(5) "Navigable Waters Servitude Doctrine reaffirmation; and (6) protective structures construction (riprap, piling, etc.).The physical parameters of this study are already under investigation by CRREL.

Environmental Concerns

This activity is a compensatory measure for the anticipated adverse effects of vessel movement and icebreaking during the extended season. There presently is an ongoing study to determine the specific location of these areas and the specific causitive factors.

Since active erosion is occurring along some parts of the shallow shoreline habitats, this area may be of somewhat limited value as habitat for fish and wildlife. These areas may be relatively devoid of food and cover because of the constant shifting of bottom materials. Accordingly, studies should be initiated to determine specific fish and wildlife use and impacts, as well as the causative factors of erosion. The remedial erosion control measures presently proposed also could have adverse as well as beneficial environmental effects. However, the magnitude of damages or benefits resulting from the installation of remedial erosion control measures is unknown, and studies to determine and document the effects of these proposed remedial measures would be appropriate.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Bottom features - soil and sediment types (presently under study)

2. Sediment transport (presently under study)

3. Water current patterns (presently under study)

4. Erosion rates (presently under study)

5. Causative factors - vessel movements, bottom scouring (natural icebreaking), storms, waves, seiches, etc. (prsently under study)

B. Biological

1. Benthos - population dynamics
2. Fish - population dynamics, use and value of littoral zone
3. Waterfowl - use of littoral zone
4. Mammals - use of near shore areas
5. Wetland survey
6. Terrestrial habitat values and annual loss rates - wildlife resource

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project-induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate, or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	10	$ 476,000
Appraisal	1	47,600
Base Condition Updatae	5	238,000
Monitoring	12	571,200
Evaluation	2	95,200
Totals	30	$ 1,428,000

Location and Number of Studies

Studies should be initiated in active erosion areas within each different bottom type. In addition, there should be at least three study areas each within the St. Marys and the St. Lawrence Rivers, and one each within the St. Clair and Detroit Rivers. It is presently anticipated that these 8 study sites would be adequate. Information obtained from these studies should be pertinent to related vessel speed and movement studies.

Timetable of Studies

These studies should be initiated at least two years prior to preparation of the EIS so that remedial measures could be incorporated. If the study results are to be used in evaluating the various alternatives, the studies should be initiated as soon as the actively eroding areas are identified. This data base should be subsequently updated at least two years prior to construction at a level of 50 percent of the original inventory costs.

Contingencies

If, during the monitoring phase, unanticipated beneficial or adverse environmental effects are observed, additional studies to adequately document these effects would be initiated.

OPERATIONAL MEASURE #14 - ISLAND TRANSPORTATION ASSISTANCE

This activity includes operation of a bubbler-flusher at the mainland slip for the Sugar Island Ferry. Further engineering studies at Drummond Island and Hansens Island Ferries to determine possible impacts and the provision of an ice breaking.

Operational Measures 7 & 8 include environmental studies for installation of these facilities. Operation of the airboat at Lime Island should not have significant environmental effects, and additional studies do not appear warranted.

OPERATIONAL MEASURE #15 - CONNECTING CHANNEL OPERATIONAL PLAN

This activity includes contingency plans for utilizing the U.S. Coast Guard's Icebreaking Tugs for ferry assistance in the event that icebreaking assistance and ice forecasting are inadequate. However, ferry service assistance across the St. Clair, Detroit and St. Lawrence Rivers is expected to be minimal.

Insignificant effects on the environment from this activity are anticipated and environmental studies do not appear necessary.

OPERATIONAL MEASURE #16 - WATER LEVEL MONITORING

This activity provides for the installation of additional monitoring stations, with the number and locations to be determined at a later date. These monitoring stations would include a well-house structure located near the shoreline in developed areas so that vandalism could be minimized and maintenance could be facilitated through local service. These structures would be relatively small in size (usually 8' x 8') to house an excavated well and inlet pipe.

The adverse environmental impacts associated with the construction and operation of these structures should be insignificant, and studies do not appear necessary. However, to fully minimize possible adverse effects, the U.S. Fish and Wildlife Service would participate in selecting site locations.

OPERATIONAL MEASURE #17 - VESSEL OPERATIONS

This activity includes vessel speed regulations, a responsibility of the U.S. Coast Guard and the St. Lawrence Seaway Development Corporation. These agencies have enforcement authority for the regulations found in the following U.S. Code of Federal Regulations: 33 CFR 92.49 for the St. Marys River; 33 CFR 162.135 for the St. Clair and Detroit Rivers; and 33 CFR 201.28 for the St. Lawrence River. Vessel speeds are presently monitored by these agencies using either Doppler Radar or by measuring the time a vessel takes to travel its own length. Vessel speeds are checked at random locations and times. Vessel speeds can be expected to range up to 15 miles per hour depending upon the established speed limits. Shoreline erosion and structure damage caused by navigation and natural forces are being studied on a system-wide basis by CRREL.

Environmental Concerns

Vessel movement and high vessel speeds are believed to cause some of the more severe environmental damages. The powerful propeller wash and vessel-induced waves can cause bottom scour, sediment movement and transport, high current velocities, destruction of aquatic vegetation, and ice breakup and movement. Thr resulting effects could reduce or destroy fish and wildlife resources and related habitats and/or severely damage or destroy shoreline habitats. In addition, pollutants, such as saturated hydrocarbons, heavy metals, and PCB's, could be resuspended and redistributed with resulting significant adverse effects on fish and wildlife resources and associated human uses.

Environmental damages appear to be occurring in the St. Marys, St. Clair, and Detroit Rivers and could occur with extended winter navigation in the St. Lawrence River. In addition, environmental damages appear to be occurring in some of the shallow bay areas of the system, including the following: Whitefish Bay, Saginaw Bay, Green Bay, Maumee Bay, and the West Basin of Lake Erie. Similarly, harbors adjacent to shallow water areas through which vessels would traverse could experience environmental damages from the ship-induced waves.

In order to properly assess the environmental effects of vessel movements and speeds, the following studies would be initiated.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Sediment and soil composition - under study
2. Sediment transport and turbidity - under study in selected areas
3. Hydrology - current patterns, etc. (under study)
4. Shoreline erosion - under study in selected areas
5. Shore structure damage - under study in selected areas
6. Water quality - saturated hydrocarbons, PCB's, heavy metals

B. Biological

1. Fish - population dynamics
2. Wildlife - population dynamics
3. Benthos - population dynamics
4. Aquatic vegetation - species composition and density
5. Commercial and recreational fishing - vessel effects on catch

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical, and/or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project-induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate, or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	10	$ 476,000
Appraisal	2	95,200
Base Condition Update	5	238,000
Monitoring	10	476,000
Evaluation	2	95,200
Totals	29	$1,380,400

Location and Number of Studies

Study sites should be located in lake and river bottom areas with shallow, flat cross-sections containing relatively narrow navigation channels. In these areas, the ship comprises a significant portion of the navigation channel; thus waters are displaced into shallow water zones and onto the shore. As a result, the disruption of shallow water bottoms and associated shore erosion and shore structure damage could be significant. Areas that could experience such adverse impacts are highly evident in the St. Marys, St. Clair, Detroit, and St. Lawrence Rivers, as well as as well as select harbors and shallow embayments of Green Bay and Saginaw Bay. An initial review indicates that there could be more than 20 specific locations where this is occurring or could occur. However, many of these areas are relatively close together, and several locations could be combined into one study site so that the total number of studies could be reduced to approximately 15.

Timetable of Studies

The base condition inventory would have to be initiated at least three years before completion of the Phase I GDM to allow time to acquire the data, make an appraisal, and formulate a decision among the alternatives prior to submission of an EIS. The monitoring would take place during construction and subsequent operation. There could be a lapse between the intensive base condition inventory study and the monitoring effect. The base condition data would be updated with an effort estimated to be 50 percent of the original study costs. This would be a two-year study effort immediately preceding construction.

Contingencies

In the event that unforeseen but related damages to the environment are observed in contiguous areas, additional monitoring studies should be implemented. If these studies further indicate that systematic damages also are occuring, a system-wide study should be immediately implemented. If, in any event, inordinate damages are observed, a provision should be made to halt vessel passage until an environmentally acceptable alternative course of action is implemented.

OPERATIONAL MEASURE #18 - SAFETY/SURVIVAL REQUIREMENTS

This activity includes the research and development of safety and survival equipment and the changing of applicable regulations to test such equipment. No significant adverse environmental impacts are anticipated, and studies do not appear warranted.

OPERATIONAL MEASURE #19 - VESSEL OPERATING AND DESIGN CRITERIA

This activity includes criteria for hull strengthening, increased vessel power, strengthened vessel gears and propellers, and special anti-freeze sea chest arrangements. Since these appear to be "criteria" and not regulations, implementation would be the responsibility of the ship owners. Although many present vessels traveling the Great Lakes could not comply with these criteria, ships built in the future may be required to meet such specifications.

Increased vessel horsepower and strengthened propellers could result in adverse environmental impacts, such as increased sedimentation and turbidity and the destruction of fish and other aquatic life.

The studies necessary for the increased horsepower and strengthened propellers are incorporated under Operational Measure #17.

OPERATIONAL MEASURE #20 - SEARCH AND RESCUE REQUIREMENTS

This activity includes using icebreakers and all weather aircraft to respond to emergency situations. Ice breaker requirements are discussed under Operational Measure #1, and all weather aircraft presently operate in the area.

The environmental effects associated with icebreakers are presented on Operational Measure #1, and the continued operation of aircraft should not result in additional environmental effects. Accordingly, studies do not appear necessary.

OPERATIONAL MEASURE #21 - VESSEL WASTE DISCHARGE (NON-HUMAN) REQUIREMENT

This activity is a study of the facilities necessary to accommodate the "no discharge regulations" and the regulation for the equivalent of secondary waste treatment on shipboard. It also would determine the adequacy of facilities. Preliminary results of this study were presented to the Working Committee at the September 1978 meeting. These results indicate that facilities are adequate at most ports, and that some ships, especially those recently constructed, have adequate holding or treatment facilities. However, most operating ships presently do not have adequate holding or treatment facilities. Environmental studies do not appear necessary for this activity because vessel wastes contribute a very small amount to the total waste load at any single point on the lakes.

OPERATIONAL MEASURE #22 - ENVIRONMENTAL PLAN OF ACTION

This activity provides for the development of a plan that identifies the environment studies needed to evaluate all operational development. This plan, as presently constituted, includes 71 site-specific and 11 system-wide types of study. These studies are comprehensive in nature and include both physical and biological parameters. The studies would require about 2,700 man-years of effort, would take about 15 years to complete and would cost about $130 million.

The funding for this activity (EPOA Development) is provided for under existing appropriations.

OPERATIONAL MEASURE #23 - PILOT ACCESS

This activity provides for the acquisition of two icebreaking tugs for the transfer of pilots to and from ships at Cape Vincent, New York, and one icebreaking tug each at Detroit and DeTour, Michigan. These do not have icebreaking capabilities. Since these tugs would be approximately 50 feet in length, the construction of berthing facilities may be required.

Environmental Concerns

The icebreaking activities and the construction of berthing facilities each raise environmental concerns similar to those expressed under Operational Measures #1 and 2, respectively. The environmental effects by icebreaking activities should be minimal in view of the relatively shallow vessel draft (12 to 18 feet). However, the berthing facilities for these vessels may require more space than presently utilized by the launches. Thus, site locations would be critical with respect to the location of wetlands, dredging activities, and dredged material placement.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Water quality - turbidity, heavy metals and PCB's

2. Bottom quality - pollutant content

3. Sediment transport - within and outside of the channel

4. Water current - patterns and velocities

B. Biological

1. Fish - population dynamics and use within the navigation channel and between harbor and pickup point

2. Benthos - population dynamics both within the navigation channel and between harbor and pickup point

3. Aquatic vegetation - composition, density, and location

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base condtions and monitoring data would be made and evaluated to determine project induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects.Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	4	$ 190,400
Appraisal	1	47,600
Base Condition Update	2	95,200
Monitoring	8	380,800
Evaluation	2	95,200
Totals	19	$ 809,200

Location and Number of Studies

The study sites would extend from DeTour Harbor, MI, the Port of Detroit, MI, and Cape Vincent, NY, to the pilot pickup point in the St. Marys, Detroit, and St. Lawrence Rivers, respectively.

Timetable of Study

The base condition inventory would have to be initiated at least two and one-half years before completion of the Phase I GDM to allow time to acquire the data, make an appraisal, and formulate a decision among the alternatives prior to submission of an EIS. The monitoring would take place during construction and subsequent operation. There could be a lapse between the intensive base condition inventory study and the monitoring. The base condition data would be updated with an effort estimated to be 50 percent of the original study costs. This would be a two-year study effort immediately preceding construction.

Contingencies

In the event that unforeseen damages are observed during construction or during the monitoring effort, a provision should be make to halt or modify the development until modifications can be made that would minimize, eliminate, compensate, or mitigate such damages.

OPERATIONAL MEASURE #24 - CHANNEL CLEARING CRAFT

This activity, still in the conceptual phase, includes craft to clear mush ice from the vessel track of Duluth-Superior Harbor and the St. Lawrence River. This craft could be a large wide-beam clearing barge pulled by a towing vessel, possibly a buoyant-screw type ice tractor. The barge would be pulled along in the vessel track and would push the mush ice to the side of the vessel track in the Lake St. Lawrence and Duluth- Superior Harbor.

Environmental Concerns

Since this development is still in the conceptual stage and no firm proposal has been formulated, appropriate studies cannot be proposed. However, if ice is cleared from the channel, ice ramparts would be formed on both sides and adverse environmental effects could be anticipated. Accordingly, several selected channel reaches would be studied to document such effects and form a basis to recommend, if appropriate, alternative actions.

OPERATIONAL MEASURE #25 - VESSEL CAPTAIN AND PILOT TRAINING

This activity includes a comprehensive training program to enhance the capabilities of ship masters and pilots. Adverse environmental effects are not anticipated with this activity, provided adequate training safeguards are implemented. Accordingly, the need for environmental studies is not anticipated.

B. HARBORS

OPERATIONAL MEASURE #B-1 - HARBOR ICEBREAKING

Ship movement in select harbors would require icebreaking assistance within the harbor (within the breakwaters). It is presently proposed that commercial harbor tugs provide this assistance, and that the costs for this service would be borne by the ship owners and/or port authorities. The specific harbors where these services would be required are as follows:

1. Duluth - Superior - a long river harbor
2. Marquette-Presque Isle- breakwater harbors
3. Escanaba- on Green Bay
4. Green Bay- a long embayment harbor
5. Muskegon- a secondary lake harbor
6. Ludington - a secondary lake harbor
7. Alpena - a breakwater harbor area
8. Saginaw - a long embayment harbor with a dredged channel into the bay
9. Monroe - a long river harbor with a dredged channel into the lake
10. Toledo - a long river harbor with a dredged channel into the lake
11. Huron
12. Buffalo - a long harbor

In addition, it is anticipated that high horsepower, icebreaking tugs would be needed at the following additional harbors:

1. Ashland - a long, large embayment harbor
2. Sandusky - a long large embayment harbor

In the latter two areas, the open lake is miles from the docks through rather large bays, thus a more powerful icebreaker would be necessary.

Environmental Concerns

Basically, the environment concerns with regard to icebreaking in harbors are similar to those expressed about icebreaking the the lakes and connecting channels (i.e., Operation Measure #1). However, because of the presence of highly polluted bottom materials, the sediment movement would be more critical in harbor areas. Even though less turbulence is anticipated with smaller tug activities, the adverse effects of these activities on fish and wildlife resources and associated habitats would be essential.

Environmental Studies

The environmental studies for icebreaking in harbors are similar in nature to those proposed to be conducted for the lakes and associated connecting channels.

I. Resource Inventory (Base Condition)

   A. Physical

      1. Water quality - turbidity, heavy metals, PCB's and other toxicants
      2. Sediment transport - in channel and out channel
      3. Water current patterns and velocities - with and without ramparts

   B. Biological

      1. Fish use of navigation channel
      2. Fish population dynamics
      3. Fish migration and spawning patterns
      4. Benthic population dynamics - in and outside of the channel
      5. Terrestrial animal use of waterway (movement)
      6. Aquatic vegetation - species composition, density and location

II. Appraisal - the information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/or physical indicators that would be monitored. The information from this appraisal would be used by the OCE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	4	$190,400
Appraisal	1	47,600
Base Condition Update	2	95,200
Monitoring	4	190,400
Evaluation	1	47,600
Totals	12	$571,200

Location and Number of Studies

Each of the previously listed harbor ice boom configurations would be studied. This would amount to a total of 14 studies.

Timetable of Studies

Studies should be conducted to allow completion of base condition inventories prior to preparation of an EIS for ice boom installations. The base condition update studies would be initiated two years immediately preceding construction with a projected cost of 50 percent of the base condition inventories. Monitoring studies would commence with construction and continue into the operation phase so that changes would be documented. However, the actual project timetable would dictate study limitation dates.

Contingencies

In the event unforeseen inordinate damages occur, studies to monitor such impacts would be undertaken. Provisions also should be made to suspend construction or the placement of the ice booms until an environmentally acceptable alternative could be implemented.

OPERATIONAL MEASURE #B-2 - HARBOR ICE CONTROL STRUCTURES

It would be necessary to reorient or modify harbor entrances with the installation of booms to prevent the shifting of ice and/or the drifting of lake ice into the entrances. As presently planned, the entrance of the following harbors would be modified.

1. INDIANA Harbor
2. Muskegon
3. Saginaw
4. Ludington
5. Huron
6. Lorain
7. Cleveland
8. Ashtabula
9. Conneaut

The configuration of the ice boom varies from harbor to harbor. These configurations are presented in Appendix B of the Survey Report.

Environmental Concerns

The environmental concerns related to the installation of these structures differ from the previously expressed for the installation of ice booms in the lakes, rivers, and connecting channels. Stabilizing ice conditions at harbor entrance could induce changes in current patterns and subsequent sedimentation of suspended materials in new and productive areas. The anchoring devices may need to be dredged in place, thereby disrupting and/or destroying productive fish and wildlife habitat, including vegetation beds and spawning grounds. Accordingly, these developments should be studied to determine their effects on the fish and wildlife resources, including their habitats.

Environmental Studies

A typical study for harbor entrance ice booms would be similar to those studies proposed for the installation of booms in the lakes, rivers, and connecting channels (Operational Measure #7). However, it is anticipated that only the water levels and flows on the affected harbor would be impacted. The resulting absence of ice jams at harbor entrances could result in more stable harbor water conditions.

I. Resource Inventory (Base Condition)

A. Physical

1. Water quality - turbidity, heavy metals, PCB's and other toxicants

2. Sediment transport and depositions - pattern changes

3. Water levels and flows - changes and fluctuations

B. Biological

1. Fish use - nursery, spawning, feeding, etc.

2. Fish population dynamics

3. Fishing use

4. Benthic population dynamics - in and outside harbor entrance

5. Aquatic vegetation - species composition, density and location - in and outside harbor entrance

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical and/or physical indicators that would be monitored. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	8	$ 380,800
Appraisal	1	47,600
Base Condition Update	4	190,400
Monitoring	8	380,800
Evaluation	2	95,200
Totals	23	$1,094,800

Location and Number of Studies

Studies should be conducted in each of the harbors that would have icebreaking services. This is a total of 9 study site locations.

Timetable of Study

Studies should be initiated to allow completion of the base condition inventory prior to preparation of an EIS for harbor operations. Since a number of the harbors support all-year vessel traffic, studies in those areas should be initiated forst. The base condition update studies would be conducted at a level of effort of 50 percent of the original study costs and should be started at least two years prior to construction. Monitoring studies would commence with construction and continue a sufficient time into the operational phase to document changes. However, the actual project timetable would dictate study initiation data.

Contingencies

In the event that unanticipated damages to the environment are observed, studies to document such impacts would be undertaken. In addition, provisions also should be made to halt construction until an environmentally acceptable alternative could be implemented.

OPERATIONAL MEASURE #B-3 - HARBOR AIR BUBBLER SYSTEMS

This activity provides for the installation of air bubbler systems along docks and in berthing areas and turning basins of harbors. These systems would be operated in a similar manner to those proposed for the connecting channels (Operational Measure #8). These systems are proposed in the follwing harbors:

1. Duluth - Superior
2. Ashland
3. Marquette
4. Escanaba
5. Calumet
6. Alpena
7. Monroe
8. Sandusky
9. Huron

Environmental Concerns

The installation and operation of harbor air bubbler system could result in both beneficial and adverse environmental effects, particularly with regard to fish and wildlife resources. The effects described in the section Environmental Concerns under Operational Measure #8 would be applicable for the turning basins. However, it is anticipated that the adverse impacts associated with the installation of bubbler systems along docks and in berthing facilities would be reduced since these bubbler systems would be attached to the structures. In such instances, it is anticipated that installation would be accomplished by individual dock and berthing facility owners under provisions of a Department of the Army permit issued by the Corps of Engineers. If the installation of these bubbler systems is further contingent upon the authorization of the Extended Season Program by the Congress, then the issuance of such permits should be held in abeyance until authorization is obtained.

Environmental Studies

I. Resource Inventory (Base Condition)

A. Physical

1. Water quality - background, oxygen content, etc.

2. Hydrology

B. Biological

1. Waterfowl use (year-round)

2. Fish - population dynamics (species composition and winter use of area)

3. Benthos - population dynamics

4. Plankton - open water in winter

II. Appraisal - The information gathered on base conditions would be evaluated in relation to expressed concerns to determine the biological, chemical, and/or physical indicators that would be monitoried. The information from this appraisal would be used by the COE during environmental assessment and EIS preparation.

III. Base Condition Update - Selected indicators would continue to be sampled prior to construction to maintain an accurate base condition description or document changes.

IV. Monitoring - This stage of the study would gather the necessary data during the operation phase to make a comparison and a determination of the nature and extent of the effects.

V. Evaluation and Report Preparation - A comparison of base conditions and monitoring data would be made and evaluated to determine project-induced changes. If appropriate, recommendations would be formulated to eliminate, mitigate, or compensate for adverse environmental effects. Reports would be submitted to the Corps for appropriate action.

Type of Study	Level of Effort (Man-Years)	Costs
Inventory	4	$ 190,400
Appraisal	1	47,600
Base Condition Update	2	95,200
Monitoring	8	380,800
Evaluation	2	95,200
Totals	17	$ 809,200

Location and Number of Studies

A study would be made in each of the 9 harbors to determine the effects of the bubbler systems on fish and wildlife resources.

Timetable of Studies

Studies initiation should coincide with the projected project timetable, with base condition updating studies commencing two years prior to construction. Monitoring studies would take place during construction and operation.

Contingencies

In the event unforeseen inordinate damages are observed, provisions should be made to suspend construction or operation until an environmentally acceptable alternative plan could be implemented.

OPERATIONAL MEASURE #B-4 - HARBOR NAVIGATION AIDS

This activity is similar to that described in Operational Measure #6, with the navigation aids located in or near specific harbors. The following is a listing of the number of navigation aids by harbor:

Duluth - Superior - 6 fixed navigation lights

Green Bay - 4 fixed navigation lights

Saginaw Bay - 2 fixed navigation lights

Alpena - 1 fixed navigation light

Toledo - 1 fixed navigation light

These aids would be placed on tripods or other permanent structures such as a caisson of suitable size to withstand the winter elements.

Environmental concerns

These structures could cause localized, minor adverse environmental effects, the severity dependent upon specific site locations. However, the placement of these structures at the edge of the dredged cahnnel would further minimize the impacts.

Since anticipated adverse environmental effects would be minimal, studies do not appear to be necessary. However, the Service would participate in the planning of structure locations so that environmental damages would be minimized or eliminated.

C. SYSTEM-WIDE STUDIES

STUDY MEASURE #C-1 - ECOSYSTEM ANALYSES

The Ecosystem Analyses studies (characterizations) would synthesize existing information and data (published and unpublished) in a manner structured to identify functional relationships between processes and components of the various subsystems of the Great Lakes/St. Lawrence system. The 15 subsystems studies have been identified for study are as follows:

Lake Superior - 2 studies
St. Marys River - 1 study
Lake Huron - 3 studies
(St. Clair-Detroit System characterization is considered complete)
Lake Michigan - 3 studies
Lake Erie - 3 studies
Lake Ontario - 2 studies
St. Lawrence River - 1 study
(U.S. portion)

Each of the above subsystem studies would be linked so that the environmental effects and/or impacts could be viewed systematically for the entire system. Each of the subsystem studies will:

1. Assemble, review and synthesize existing biological, physical and socioeconomic information and establish a sound ecological information and data base for decisionmaking purposes.

2. Identify and describe various components (subsystems, habitats, communities and key species).

3. Describe major physical, biological and sociological components and interactions.

4. Describe known and potential ecosystem responses to man-induced changes emphasizing extended winter navigation.

5. Identifying major information deficiencies for further study and decisonmaking needs to assess impacts of extended navigation program.

Each study would require 2 years to complete at estimated cost $809,200 per study. The products from these studies would include ecological atlases, narrative reports, a computerized Geobased Information System (GIS) for each subsystem (collectively these data bases would form GLIMS—the Great Lakes Information Management System to be managed by the FWS), models, and an extensive and comprehensive reference library.

As can be seen, these studies are geographically oriented and are designed to acquire the existing data, present it in a concise form and identify data gaps. The remainder of the systemwide studies are resource oriented and will provide data, both existing and generated, for comparison with the data generated by monitoring studies after the developments have been constructed or in operation. For this reason, these studies should be completed before the individual baseline studies begin. If this is accomplished, the literature search portion of the baseline studies can be eliminated. This would allow a further saving of study time and money, if these characterizations are available to all field workers.

STUDY MEASURE #C-2 - WETLAND SURVEY (COMPLETED)

The results of this ongoing study provides a compilation and listing of the wetlands in the U.S. portion of the Great Lakes system. This listing includes the classification, sizing and location of individual wetlands in accordance with FWS standards for the National Wetlands Inventory. The Great Lakes portion of the National Inventory is an accelerated effort so that the availability of information would conform to the Extended Season Program timetable. The Great Lakes inventory is a 2-year effort that was initiated in 1978. This effort was cost shared by both the FWS and Corps at a cost of $277,000 and $380,000, respectively. Products delivered include the acquisition of aerial photography (new or existing), photo interpretation, mapping and typing of wetlands, quarterly and yearly progress reports, and a final report. The final report, in conjunction with the map overlays and aerial photography will be of sufficient detail to locate, size and classify existing wetlands.

The completed wetlands survey for the Great Lakes system will be used as base condition information in assessing and evaluating the direct effects of extended winter navigation (i.e., project construction) as well as the associated secondary effects (e.g., the siting or enlarging industrial developments, power plants and port facilities, and urbanization).

STUDY MEASURE #C-3
FISH SPAWNING AND NURSERY GROUND ATLAS (COMPLETED)

This is an ongoing system-wide study designed to provide existing information and data, in the form of an Atlas, on the spawning and nursery grounds of the important commercial and sport fishes of the Great Lakes system. The Atlas contains maps on the location, area size and use by fish species, time of year, length of time, etc. Also included are narrative descriptions of the important sport, commercial, forage and nuisance species as well as ecologically endangered, threatened and sensitive species. In addition, information and/or data gaps are identified.

This 2-year study was initiated in 1978 at a cost of $177,000. Much of the information to be obtained through this study is historic data and relatively available, but in need of consolidation. The impacts of extended winter navigation on these important areas cannot be properly assessed until this information becomes available. These impacts, even though localized, could extend over vast areas in view of the mobility and migrating behavior of the fish species.

STUDY MEASURE #C-4
IMPACT OF EXTENDED WINTER NAVIGATION ON MIGRATORY BIRDS IN SYSTEM

Winter vessel operations in nearshore areas could adversely effect the feeding, breeding, nesting, and resting habitats for as many as 300 species of migratory, resident, and wintering birds. This list includes a variety of waterfowl; shore, marsh, and wading birds; raptors; and song bird species. This study would provide a base of information for correlating changes induced through extended winter navigation, as well as a mechanism for monitoring and evaluating the impacts.

A 2-year effort to accumulate base information has been initiated. The result of this study determines the locations of major nesting and resting areas, wintering bird concentrations and wintering food supplies, as well as the habitat requirements for spring and fall migrants. The monitoring and evaluation of impacts would take an approximate additional 7 years. Specific sites would be selected as representative of a region. The objective of the base information phase is to:

1. Compile and synthesize all currently available information on wintering populations of migratory birds.

2. Prepare location maps indicating concentrations of birds potentially affected by extended winter navigation.

3. Determine the effects of extended winter navigation on wintering birds.

4. Determine bird use of ship channels, harbors, and open water areas during winter months.

5. Determine and assess the impacts of extended winter navigation on the breeding, resting, nesting, and feeding ground of the system.

This study would provide a comprehensive literature review, petinent aerial photography, ground and aerial censuses, mapping of breeding, resting, nesting, and feeding grounds and migratory routes, establish study site locations for monitoring, assess the food requirements of major waterfowl species, and determine the location of available food resources. The products will be in the form of summary and progress reports, with a final narrative report which will include the literature review , aerial photos and finished maps.

The base condition inventory data should be updated at a level of effort equal to 50 percent of original costs. This effort should be initiated 2 years immediately prior to construction at an estimated cost of $125,000.

The monitoring studies would be initiated during construction and span a period of 5 years. The final product would be a report detailing the system-wide effects of extended winter navigation. This report also would contain recommendations to eliminate or minimize the adverse effects of extended winter navigation on avian resources. At an estimated cost of $238,000 annually, the monitoring study cost would total $1,190,000. This would be a total of $1,315,000 for the study that is yet to be funded.

STUDY MEASURE #C-5
COMMERCIAL FISHING AREAS AND PORTS AND EXTENDED WINTER NAVIGATION IMPACTS THEREON

This system-wide study would be designed to provide information and data on the location, type of fishery (gear use, species sought, and incidental catch), and special landings, by sub-area. Extended winter navigation could either directly or indirectly effect commercial fishing activities.

The direct effort of extended winter navigation and associated vessel activities could be the creation of unsafe ice conditions for fishing, the removal of fish from traditional fishing grounds, the elimination of fishermen access to traditional fishing areas, and the destruction or loss of fishing gear. Secondary or indirect effects could be a reduction in recruitment to the fishery resource (e.g., reduced spawning and nursery habitat and associated use, reduced available food supplies, etc.). Several states are presently assessing selected fish stocks during the normal closure of the general commercial fishery season, and these programs also may be adversely affected.

The base condition inventory studies would be a 2-year effort designed so that localized and cumulative effects could be evaluted. The 2-year monitoring effort would be initiated to assess the impacts of extended winter navigation on the commerical fishing industry. Thus, this study would be in two phases, the first phase being the acquisition and evaluation of base conditions and the second phase, the monitoring of areas influenced by extended winter navigation and document changes.

The estimated cost for the base condition and monitoring phases are approximately $428,400 and $714,000, respectively. The total estimated cost for both the base condition and monitoring studies is $1,142,400.

Type of Study	Level of Effort (Man-Years)	Cost
Baseline	4	$ 190,400
Evaluation	1	47,600
Baseline Update	4	190,400
Monitoring	13	618,800
Validation	2	95,200
Totals	29	$1,142,400

STUDY MEASURE #C-6
SPORT ICE FISHING AREAS AND EXTENDED WINTER NAVIGATION IMPACTS THEREON

This system-wide study would be designed to provide information and data on the location of species sought and/or caught and the days of effort spent at this activity by sub-basin. Extended winter navigation could result in direct or indirect adverse effects on this sport fishing activity.

Direct effect impacts of extended winter navigation could be unsafe ice fishing conditions, the removal of fish from traditional fishing areas and/or the elimination of access to the traditional sport fishing grounds. Secondary effects could be reduced recruitment to the fishery through destruction or reduction in spawning and nursery grounds and preferred food sources.

Several states are presently undertaking local assessments of ice fishing activities. These assessments, in conjunction with additional needed sutdies, would provide the data necessary to determine cumulative ice fishing activities within the system, as well as evaluate effects of extended winter navigation on the fishery.

This study should be conducted in two phases: Phase I - acquistion of base condition data; and Phase II - monitoring to document project induced effects.

The base condition phase would be a 2-year effort at an estimated cost of $429,400. This study should be initiated at least 2 years before construction commences. The 2-year monitoring study effort would be initiated during construction and would include aerial surveys and ground checks by sub-basin. The cost for this effort would be approximately $714,000. The estimated total cost for both the base condition and monitoring study efforts is $1,142,400.

Type of Study	Level of Effort (Man-Years)	Cost
Baseline	4	$ 190,400
Evaluation	1	47,600
Baseline Update	4	190,400
Monitoring	13	618,800
Validation	2	95,200
Total	29	$1,142,400

STUDY MEASURE #C-7 - WATER QUALITY

This study would be designed to document the effects of extended winter navigation on the water quality of the system, as well as on a lake-by-lake basis. It also would attempt to determine the effects of increased vessel transits on water quality.

The study would be conducted in two phases—base condition and monitoring. The information and data obtained from previous study efforts by State and Federal agencies could suffice as base conditions, and this should be fully explored. In the event these data are lacking, the sampling of selected parameters would be necessary, particularly in those areas where extended winter navigation would occur. The sampling methods to be used would be in accordance with established Federal procedures.

Since information as to the availability and adequacy of existing water quality data on the Great Lakes system is presently unknown, a best estimate of the costs required for this study effort was based on manpower requirements and related computer costs over a 7-year period. Based on these factors, anticipated costs would be approximately $1,456,400.

STUDY MEASURE #C-7 - WATER QUALITY

This study would be designed to document the effects of extended winter navigation on the water quality of the system, as well as on a lake-by-lake basis. It also would attempt to determine the effects of increased vessel transits on water quality.

The study would be conducted in two phases—base condition and monitoring. The information and data obtained from previous study efforts by State and Federal agencies could suffice as base conditions, and this should be fully explored. In the event these data are lacking, the sampling of selected parameters would be necessary, particularly in those areas where extended winter navigation would occur. The sampling methods to be used would be in accordance with established Federal procedures.

Since information as to the availability and adequacy of existing water quality data on the Great Lakes system is presently unknown, a best estimate of the costs required for this study effort was based on manpower requirements and related computer costs over a 7-year period. Based on these factors, anticipated costs would be approximately $1,456,400.

STUDY MEASURE #C-9
FURBEARERS AND MAMMALS, THEIR HABITATS, AND THE EXTENDED WINTER NAVIGATION IMPACTS THEREON

This study would be system-wide in nature and directed toward the identification of furbearers and mammals and their related habitats which could be affected by extended winter navigation. The cumulative effects on these animals and their habitats would be monitored over a sufficient period of time so that subtle effects could be detected. The habitats of these animals incude a variety of wetland types, as well as adjacent shore and upland areas. The data developed in Measure #C-2 (Wetlands Inventory) would be used in conjunction with this study effort. Additional data would be developed on habitat requirements for specific animal species, as well as population dynamics and species interrelationships.

The study would be two-phased: Phase 1 - a pre-operational base condition data gathering effort; and Phase 2 - a monitoring effort. Phase 1 would be further subdivided into two segments: (1) a search and data verification; and (2) a data gap filling. The literature search and data verification should be of a short duration. However, the filling of data gaps would be more extensive and could require a 5-year period prior to project operation. At the completion of Phase 1 of the study, the data would be evaluted to determine the specific species to be monitored during operations. The monitoring study (Phase 2) would extend over a sufficient period of time to assure that the subtle effects on the furbearers and mammals would be detected.

There would be about a 21 man-year level of effort, at an estimated cost of $999,600 expended on the literature search, verification of data, and filling of the data gaps. The monitoring phase of the study would be initiated during operations and would require a 24 man-year level of effort at an estimated cost of $1,142,400. The total cost for this study would be approximately $2,142,000.

Type of Study	Level of Effort (Man-Years)	Cost
Baseline	12	$ 571,200
Evaluation	1	47,600
Baseline Update	8	380,800
Monitoring	22	1,047,200
Validation	2	95,200
Totals	45	$2,142,000

STUDY MEASURE #C-10
THREATENED OR ENDANGERED SPECIES AND THEIR CRITICAL HABITAT WITH THE IMPACTS OF EXTENDED WINTER NAVIGATION THEREON

This system-wide study would be designed to identify all Federal and State classified threatened and endangered plant and animal species using the waters and adjacent shoreline and upland areas of the Great Lakes system. In addition, their critical habitats would be defined and delineated, and the anticipated impacts of extended winter navigation would be documented. The compilation of species, related habitats, and habitat requirements would be obtained from the FWS and the various State fish and wildlife agencies. In the event that critical habitats and/or habitat requirements have not been determined, research studies would be immediately initiated.

The first phase of this study would consist of gathering information from published and unpublished sources and would fill existing data gaps and provide for the initiation of needed studies. The second phase would monitor the identified species and associated critical habitats during construction and operations to determine the effects of extended winter navigation.

The first phase of the study would require an estimated 21 man-year level of effort at a project cost of $999,600. The level of effort and estmated associated costs for the second phase are 24 man-years and cost about $1,142,400. The estimate total cost of this study is $2,142,000.

Type of Study	Level of Effort (Man-Years)	Cost
Baseline	12	$ 571,200
Evaluation	1	47,600
Base Update	8	380,800
Monitoring	22	1,047,200
Validation	2	95,200
Totals	45	$2,142,000

STUDY MEASURE #C-11 - OIL AND HAZARDOUS SUBSTANCE CONTINGENCY PLANS

To Date, "no major" oil or hazardous substance spills have occurred on the Great Lakes in winter. Historically, most oil spills are related to either weather damaged vessels or vessel accidents. The U.S. Coast Guard is of the opinion that adequate mechanisms are available to handle oil or hazardous substance spills in the Great Lakes year round. The current definition places spills into three subjective categories: minor discharge - 0 to 10,000 gallons; medium discharge - 10,000 to 100,000 gallons; and major discharge - over 100,000 gallons. Volume is not the best indicator of spill hazard, toxicity also plays a large part as do other physical and chemical attributes.

Present contingency plans do not include provisions for oil or hazardous substance salvage and disposal treatment since the disposal or salvage of the spilled substances are contracted to private organizations.

The U.S. Fish and Wildlife Service is involved in the implmentation of spill contingency plans with regard to impacted fish and wildlife resources.

Environmental Concerns

The concerns about the contingency plans stem from several aspects: task force or team response time (the length of time it takes for containment and cleanup personnel to arrive on a site); containment equipment response time (the length of time for proper equipment to arrive and become operational at the site); and the low efficiency of the equipment in containing and cleaning up spills (some estimates indicate that only about 50 percent of a spill could be contained). Studies are continuing on procedures and equipment for spill containment and cleanup. Under winter conditions and/or high current velocities, improved equipment and procedures are required to insure that fish and wildlife are protected.

Under these given conditions, oil and hazardous substance spills could have catastrophic effects of the fish and wildlife resources and related habitats, with the magnitude of damages dependent directly upon spill site location, and the toxicity and volume of materials. The areas that would be most vulnerable to damage include: fish spawning and nursery grounds, wetlands, waterfowl nesting and feeding areas and shallow water zones.

Three basic types of studies should be undertaken for this activity: Type I - A review of existing contingency plans: Type II - the design and development of more efficient containment and cleanup equipment and procedures for fish and wildlife protection with particular reference to winter conditions and/or high current velocities; and Type III - a thorough documentation on the environmental effects of future spills, by substance, when such occur.

The first study uder the Type I category is underway on a limited basis for the St. Marys River area. The purpose of the study is to find ways and means to shorten personnel and equipment response times. Additional studies of this type should be undertaken for the entire Great Lakes system so that the variations among and between the various contingency plans are well documented and appropriate recommendations could be made to implement a uniform, system-wide effort.

The purpose of the Type II study would be to find more efficient equipment for the containment and cleanup of spilled substances. The results of this effort also would include recommendations as to the most strategic locations for the storage of equipment.

The Type III study would be initiated immediately after spills have occurred to document short- and long- term environmental effects. These studies should be inclusive of all potential hazardous materials.

Environmental Studies

Type I - Review of continency plans. This study should be inclusive of all contingency plans (i.e., Federal, State, regional and local) with a particular view toward the provisions contined therein to protect fish and wildlife resources. This study should evaluate all contingency plans, both individually and collectively, with a view toward shortening team and equipment response times. The final report also would present recommendation for the implementation of a uniform, system-wide plan, particularly with reference to the protection of fish and wildlife resources.

Level of Effort - 2 man-years
Study Costs - $95,200

Type II - Design and development of more efficient containment and cleanup equipment for fish and wildlife protection with particular reference to winter conditions. Research for this effort should be funded on a continual basis until methods and equipment to adequately protect fish and wildlife resources are designed, tested and put into operation.

Level of Effort - 10 man-years
Study Costs - $476,000 (minimum)

Type III - In the event that a spill occurs during the winter months (i.e., ice conditions), the effects on fish and wildlife resources would be studied in detail for as long as the effects could be detected. Several types of spill conditions (e.g., loading, unloading, grounding, collision and tanker sinking) as well as the effects of each type of material on fish and wildlife resources(e.g., crude oil, refined oils, diesel fuels, gasoline, fertilizer components, pesticides, salt, acids and selected chemicals) would be included. In addition, bioassay studies would be conducted under controlled laboratory conditions to further document the effects on selected species.

Background base condition (resource inventory) information would be gathered on fish and wildlife resources through system-wide studies (Study Measures C-1 through # 10). Onsite monitoring and/or controlled laboratory studies on selected species would establish the following for each type of material:

1. Mortality
   a. Fish - as primary cause - toxicity (sublethal and lethal levels)
      - as secondary cause - food loss, etc.

   b. Benthos - as primary cause - toxicity (sublethal and lethal levels)
      - as secondary cause - habitat loss, etc.

   c. Waterfowl - as primary cause - toxicty (sublethal and lethal levels)
      - as secondary cause - food loss, loss of insulation, contaminated foods, etc.

   d. Raptors - primary - toxicity (sublethal and lethal levels)
      - secondary - loss of insulation, contaminated foods, etc.

   e. Fur animals - primary - toxicity (sublethal and lethal levels)
      - secondary - loss of insulation, etc.

2. Aquatic vegetation - effects, extent of damages (permanency)

3. Nesting and spawning areas - effects, extent of damages (permanency)

4. Water quality

5. Sediments - concentration levels in and adjacent to spill sites

A summary report of the fundings would be prepared and forwarded to the Corps of Engineers for appropriate action(s). This report also would contain the validation of environmental concerns expressed in the U.S. Fish and Wildlife Service's Fish and Wildlife Coordination Act Report.

Level of Effort - 12 man-years
Study Cost - $571,200/study (maximum)

Location and Number of Studies

These studies would take place when and where an oil or hazardous substance spill occurred in the Great Lakes system during winter conditions and/or under controlled laboratory conditions. Potentially this could include studies for each of the substance and for each type of spill, with a total stimated cost of $11,947,600. A typical breakdown of this estimated amount would be as follows:

1. Lakes Superior, Michigan, Huron and St. Marys River - 10 studies; total $5,713,000
2. Lake Erie and St. Clair - Detroit - 7 studies; total $3,998,400
3. Lake Ontario and St. Lawrence - 4 studies; total $2,284,800

Contingencies

If a study indicates that systemic damages may be occurring, the study should be expanded to encompass the entire system. Furthermore, if inordinate damages are observed or laboratory studies indicate that severe environmental damages would occur, provisions should be made to halt or prohibit, as appropriate, the shipment of such materials until safeguards are adequate.

APPENDIX F

ENVIRONMENTAL

APPENDIX F

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SECTION F-1
ENVIRONMENTAL SETTING

The region considered under the Navigation Season Extension program is the Great Lakes system. This waterway system begins with Lake Superior, the northern-most and largest of the Great Lakes. Lake Superior discharges into Lake Huron through the rapids of St. Marys Falls and St. Marys River. Lake Michigan is connected with Lake Huron by the wide and deep Straits of Mackinac. Lake Huron discharges into Lake Erie through the St. Clair River, Lake St. Clair, and the Detroit River. Lake Erie discharges into Lake Ontario through the Niagara River. From Lake Ontario, the St. Lawrence River flows 533 miles northeast to the Gulf of St. Lawrence on the Atlantic Ocean. The navigational distance by commercial vessel routes from Duluth, Minn., and Port Arthur, Ont., at the head of Lake Superior to Kingston, Ont., at the head of the St. Lawrence, are 1,160 and 1,038 statute miles respectively. The navigation distance from the southern point of Lake Michigan (Chicago) to the head of the St. Lawrence is 1,067 miles.

Historical Perspective of Navigation on the Great Lakes System[1]

One of the many difficulties obstructing development of Great Lakes navigation into a single system was the 602-foot difference in elevation between tidewater and Lake Superior. Most of this, 591 feet, occurs in three areas. The rise in the St. Lawrence River from tidewater to Lake Ontario is 246 feet. The second is a 326-foot lift over the Niagara escarpment into Lake Erie and the third is a 19-foot lift on the St. Marys River at the outlet of Lake Superior. For many years, goods were unloaded from ships at each of these barriers, transported overland, and reloaded on other ships in the Lake beyond.

[1]Great Lakes Basin Framework Study, Appendix C-9, Commercial Navigation, Great Lakes Basin Commission.

In 1680, Dollier de Casson, Superior of the Sulpician Order in Montreal, originated the concept of making a canal through the St. Lawrence River. In the early 1700's, work actually began on a canal to provide a 3-foot deep channel between Lake St. Louis and the St. Pierre River. Although never completed, it was followed by other small canals. By 1780 a series of small locks, 40 feet long, six feet wide and 2-1/2 feet deep, were in operation between Lake St. Louis and Lake St. Francis. The Lachine Canal was completed in 1825, and by 1850, a channel with maximum depth of nine feet was available from the Atlantic Ocean to Lake Ontario. The first Welland Canal across the Niagara peninsula was opened in 1829, and the improvements and modifications that formed the second Welland Canal were completed by 1844.

A major change in transportation service on the Great Lakes occurred during the mid-19th century when the demand for steel exceeded the capacity of eastern iron ore reserves. Consequently, the mines of Michigan and Minnesota became competitive.

A canal to by-pass St. Marys Falls at Sault Ste. Marie and the State of Michigan Lock (the first ship lock at Sault Ste. Marie) was completed in 1855, providing a 9-foot navigable channel from the Atlantic Ocean to Lake Superior. This facilitated economic delivery of ore to Pittsburgh furnaces. Larger vessels, terminal facilities, and complementary inland rail facilities were constructed. The rail cars and ore vessels, which normally would be empty on the back haul, were used to carry coal at out-of-pocket rates (usually half the cost of ore movements downbound) to energy-deficient Upper Lake ports and cities.

While construction of the 9-foot canal system stimulated navigation on the Great Lakes, the rapid development of the railways during the 1840's and 1850's provided stiff competition. A rail connection between Rochester on Lake Ontario and Albany on the Hudson River was completed in 1841, and

a connection between Toledo on Lake Erie and the Ohio River was finished in 1848. Chicago was connected to the east by rail in 1852, and in 1854 a line extended from Chicago to the Mississippi River. A railway from Montreal to Toronto was completed in 1856.

The effectiveness of the rail competition is reflected by the following statistics: between 1868 and 1898 total grain shipments (ship and rail) from Chicago increased from 41,000,000 bushels to 254,000,000 bushels, while the rail portion of these shipments increased from 3,000,000 bushels in 1868 to 102,000,000 bushels in 1898.

In the late 1800's, the Government of Canad undertook a new canal building program, which, on its completion in 1905, provided a minimum draft of 14 feet from the Atlantic Ocean to Lake Superior. This established much of the present traffic pattern. The use of lake freighters, which were developed solely for the movement of bulk cargoes on the Great Lakes, resulted in savings that made the Lake system again competitive with railroads.

"Since 1904 there have been a number of major changes in the navigation system in the Great Lakes which have increased the capability of the system. Among the most important was the construction of the new Welland Ship Canal completed in 1932. The seven locks were 860 feet long, 80 feet wide, and 30 feet deep over the sills. Locks of these dimensions could accommodate the lake freighters of that time. However, it was not until metallurgical developments made during and after World War II, providing steels of a greater strength and quality, that lake ships having the maximum permissible dimensions for use in the Welland Canal were constructed. It was not until after the opening of the St. Lawrence section of the Seaway in 1959 that ships 730 feet long, 75 feet wide, and drawing 25 feet of water began to appear. These ships, capable of carrying cargoes of 25,000 to 28,000 tons, were faster and more economical than their earlier kindred on the Lakes. The locks along the St. Lawrence were

similar in size to those on the Welland and Sault Ste. Marie Canals. In 1968, the opening of the new 1,200 foot-long Poe Lock at Sault Ste. Marie, which can handle ships up to 1,100 feet long, further stimulated the growth in vessel size and economy.

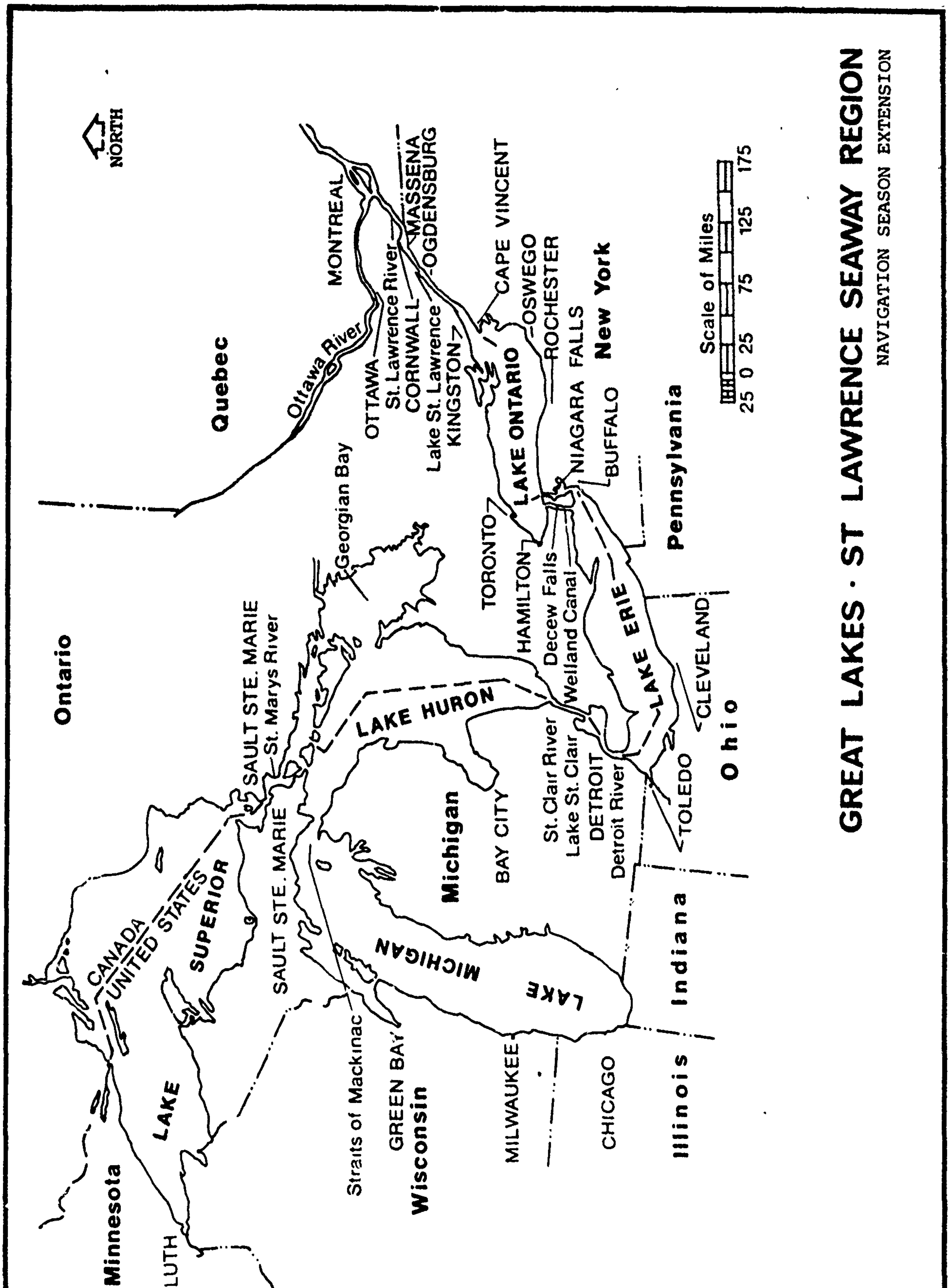
Even with the larger vessels, the entire average navigation season on the entire Great Lakes-St. Lawrence Seaway system customarily occurs between 1 April and 15 December. Any pre- or post-season extension is generally curtailed by such items as weather, severe ice conditions in the harbors, locks, lakes, and connecting channels; increased marine insurance cost; inability of vessels to operate in ice conditions; and ice booms across navigation channels in the St. Lawrence River.

Intra-lake vessel traffic has occurred prior to demonstration program, for extended navigation on Lakes Michigan and Erie and vessel traffic on the St. Clair-Lake St. Clair-Detroit River system. This vessel movement has been at the discretion of the ship companies and is largely dependent upon the severity of ice and winter conditions in the connecting channels as well as in ports of origin and destination. Navigation on the St. Lawrence River ceases when, in the judgment of the Seaway operating entities, ice and weather conditions preclude safe and efficient navigation on the St. Lawrence River.

General Description of the Great Lakes System

The basin, the lakes and the connecting rivers are shown on Figure I-1. The basin extends from 40° 30' to 50° 50' north latitude and between 75° to 93° 10' west longitude. The dimensions of the basin are approximately 700 miles in the north-south direction and 900 miles in the east-west direction.

The Great Lakes within the basin, Superior, Michigan, Huron, Erie and Ontario, with their connecting rivers and Lake St. Clair, have a water



GREAT LAKES · ST LAWRENCE SEAWAY REGION

NAVIGATION SEASON EXTENSION

Figure I-1

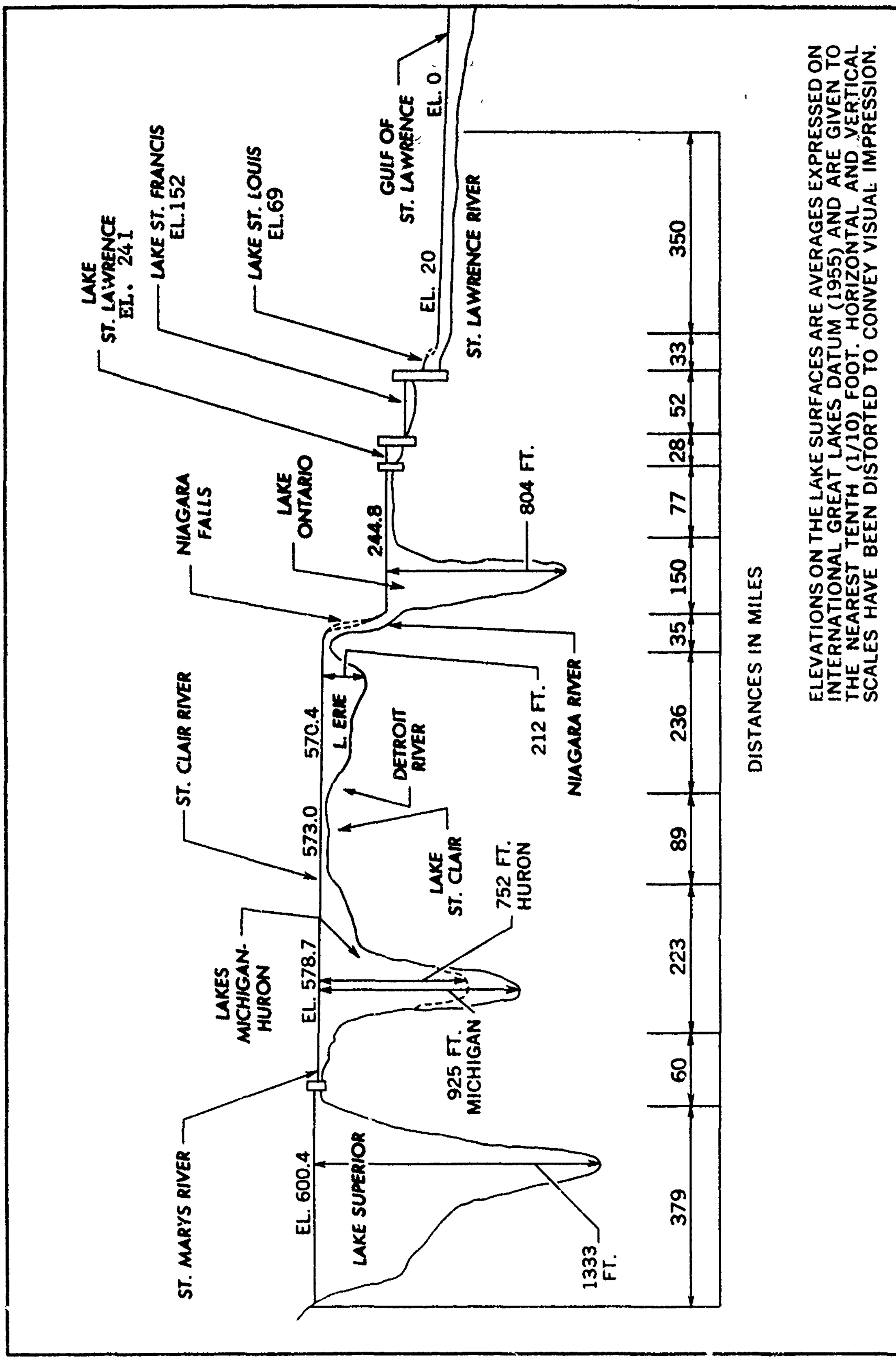
surface area of about 95,000 square miles, with about 60,800 square miles within United States boundaries. The total area of the Great Lakes Basin, both land and water, above the easterly end of Lake Ontario is approximately 296,000 square miles, with 174,000 square miles of it in the United States and 122,000 square miles in Canada. Additional data on individual lakes within the system are presented in Figure I-2.

The connecting channel rivers within the system, St. Marys, St. Clair, Detroit, and St. Lawrence* Rivers, have a combined shoreline length of 1,200 miles, of which 600 miles are within United States boundaries.

The St. Marys River, outlet of Lake Superior, flows 70 miles in a general southeast direction from Whitefish Bay on Lake Superior to Lake Huron. The river falls about 22 feet with most of the fall occurring in the mile long St. Marys Rapids reach. The flow in the river has been completely controlled since 1921 by means of a gated dam located at Sault Ste. Marie. The principal objective of this control is to compensate for the effect on Lake Superior levels of diverting water around the St. Marys River Rapids for power. The discharge of the St. Marys River during the 77 year period, 1900-1976, has averaged 75,000 cfs. Figure I-3 shows the configuration of the St. Marys River as the connecting channel between Lake Superior and Lake Huron.

The St. Clair River is the outlet of Lake Huron and flows in a southerly direction to Lake St. Clair, a distance of approximatley 39 miles (see Figure I-4) with a fall of approximatley 5 feet. The upper portion of the river is a single, relatively straight channel from its head to Algonac where it branches into a number of channels before entering Lake St. Clair. The area through which the numerous branches flow is known as the St. Clair Flats. The discharge of the St. Clair River during the 1900-1976 period averaged 180,000 cfs.

*Above power dam.



PROFILE OF THE GREAT LAKES SYSTEM

Figure I-2

Lake St. Clair is a shallow, oval shaped basin with an average depth of 10 feet and a maximum depth of 21 feet, except for the man-made navigation channel which has been dredged to a depth of 27 feet. The lake, only 26 miles long by 24 miles wide, is considered a part of the connecting channels between Lakes Michigan-Huron and Erie and contains about one cubic mile of water (3 million acre-feet).

The Detroit River flows a distance of about 32 miles from Lake St. Clair in a southwesterly direction to Lake Erie, with a fall of about 3 feet. The upper portion of the river is a deep, unobstructed channel except for Peach Island and Belle Isle at its head. The lower portion of the river is broad and is characterized by many islands and shallow expanses. The discharge of the Detroit River during the 76-year period (1900-1976) averaged about 184,000 cfs.

The Niagara River forms the natural outlet from Lake Erie, Figure I-5. It flows out of Lake Erie in a northwesterly direction to Lake Ontario, a distance of approximately 36 miles with a fall of about 326 feet. The river falls about 5 feet in the first 4 miles below Lake Erie and about 4.5 feet in the next 19 miles as it widens and divides into two channels around Grand Island. Below Grand Island it becomes one channel and in the next mile falls 55 feet in the cascades and rapids above Niagara Falls. The river drops about 185 feet over the falls into the Maid-of-the-Mist Pool which extends about 2 miles below the falls; in the next 3 miles, the river drops about 76 feet through the Whirpool Rapids to Lake Ontario. The discharge of the Niagara River at Buffalo has averaged about 198,000 cubic feet per second over the period of record (1900-1976).

The St. Lawrence River is the outlet from Lake Ontario and flows in a northeasterly direction to the Gulf of St. Lawrence, a distance of approxiamtley 530 miles with a fall of about 245 feet (Figure I-2). The major portion of this fall, some 227 feet, occurs between Lake Ontario and

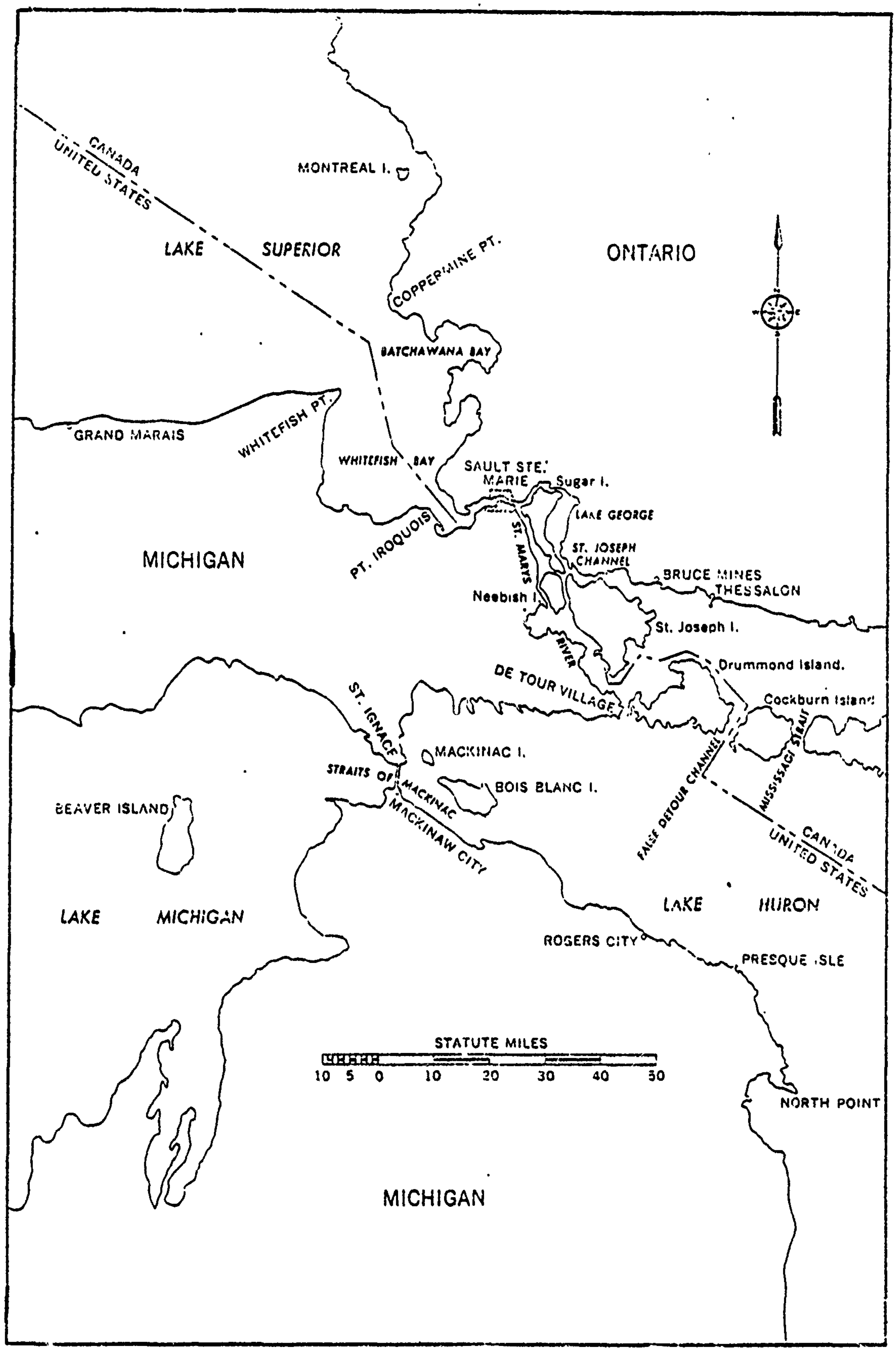


Figure I-3

MAP OF ST. MARY'S RIVER REGION

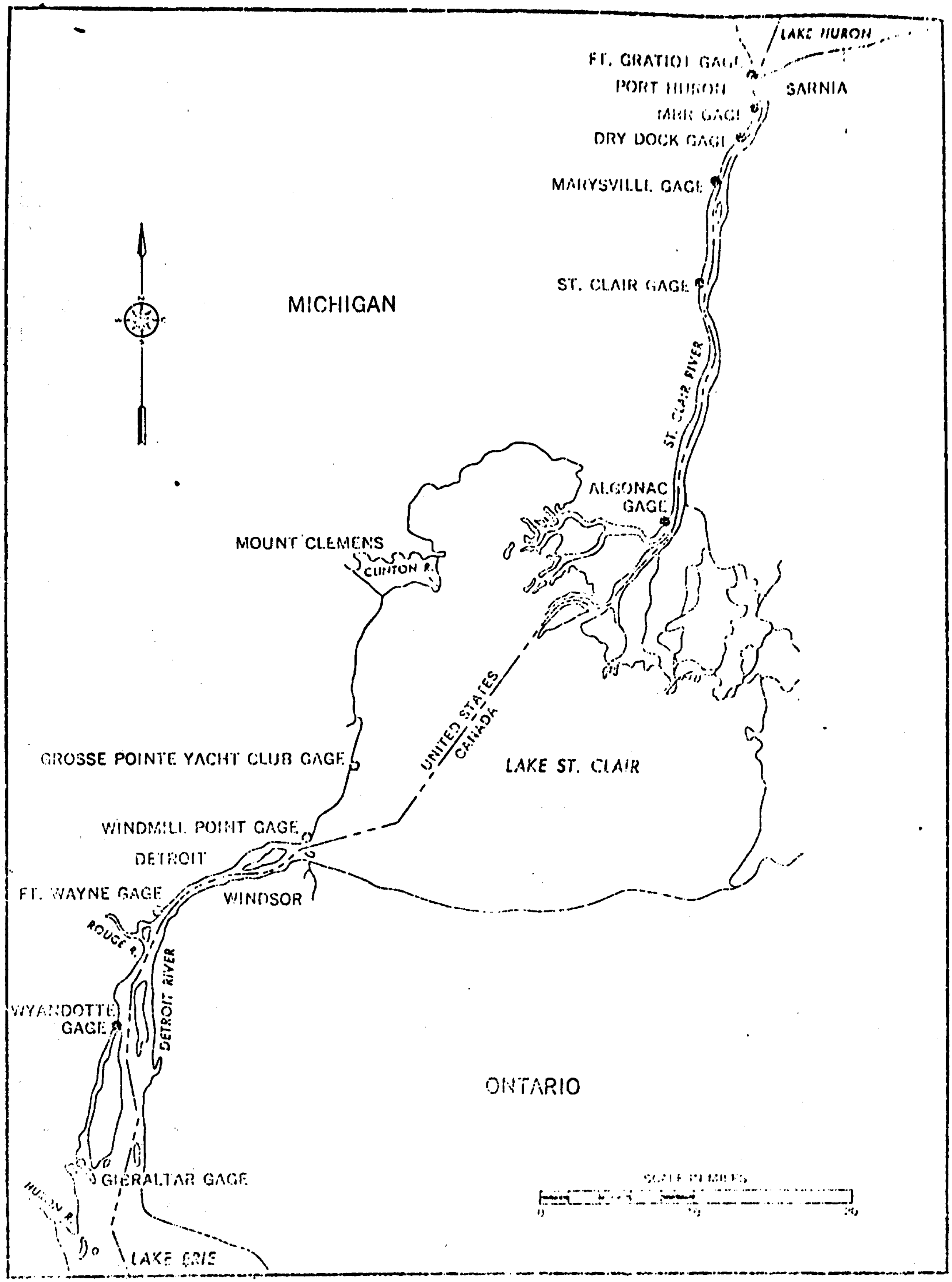


Figure I-4
ST. CLAIR-DETROIT RIVERS LOCATION MAP

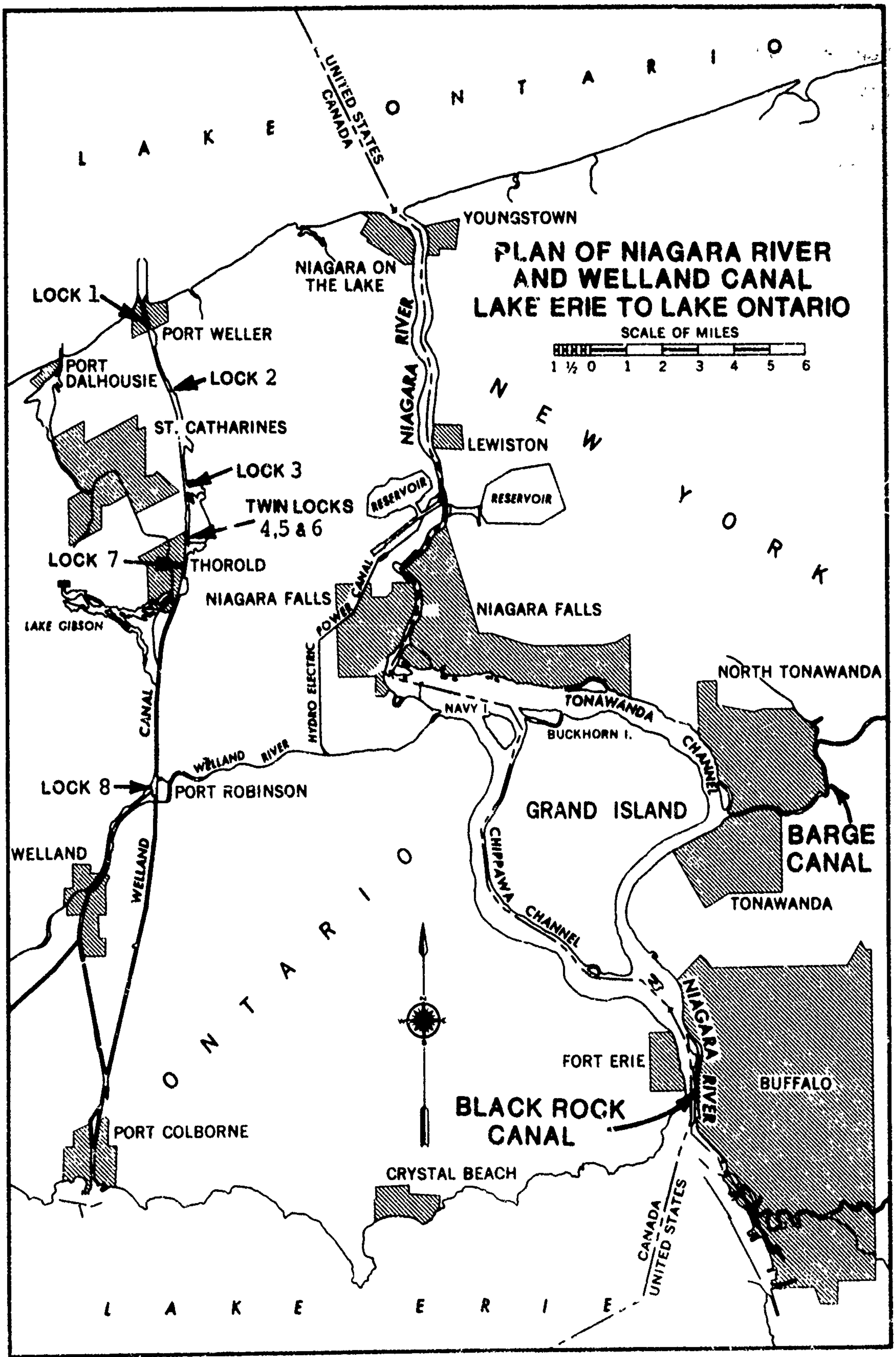

PLAN OF NIAGARA RIVER
AND WELLAND CANAL
LAKE ERIE TO LAKE ONTARIO
SCALE OF MILES
1 ½ 0 1 2 3 4 5 6
LAKE ONTARIO
UNITED STATES
CANADA
YOUNGSTOWN
NIAGARA ON THE LAKE
LOCK 1
PORT WELLER
PORT DALHOUSIE
LOCK 2
ST. CATHARINES
LOCK 3
TWIN LOCKS 4,5 & 6
LOCK 7
THOROLD
NIAGARA FALLS
LAKE GIBSON
NIAGARA RIVER
LEWISTON
RESERVOIR
RESERVOIR
NEW YORK
NIAGARA FALLS
HYDRO ELECTRIC POWER CANAL
CANAL
WELLAND RIVER
LOCK 8
PORT ROBINSON
NAVY I.
BUCKHORN I.
TONAWANDA CHANNEL
NORTH TONAWANDA
GRAND ISLAND
BARGE CANAL
TONAWANDA
WELLAND
WELLAND
ONTARIO
CHIPPAWA CHANNEL
NIAGARA RIVER
FORT ERIE
BUFFALO
BLACK ROCK CANAL
PORT COLBORNE
CRYSTAL BEACH
CANADA
UNITED STATES
LAKE ERIE

FIGURE I-5

Montreal Harbor, 183 miles from the lake. Located in this reach of the river is Iroquois Dam near Iroquois, Ontario; the Long Sault Dam between Barnhart Island and the United States shore near Massena, New York; and two powerhouses, one on either side of the International boundary between Barnhart Island and the Canadian shore near Cornwall, Ontario. These structures, built as part of the St. Lawrence Seaway and Power Project, control the outflows of Lake Ontario, which have been regulated since 1960 in accordance with criteria set forth by the International Joint Commission. Details of the regulation plan for Lake Ontario and a description of the regulatory works are provided in Appendixes B Lake Regulation, and G, Regulatory Works of the International Great Lakes Levels Board Report, Dec. 1973. A few miles below the Barnhart Island power plants, the river widens into Lake St. Francis, which, with the exception of a small area at the upstream end bounded by about 3 miles of United States shoreline, lies wholly within Canada. The levels of that lake have been fully controlled by a power plant at Beauharnois, Quebec, and the Coteau dams at the lower end of the lake since 1943. From Lake St. Francis, the river enters Lake St. Louis by the natural river channel and the Beauharnois canal. Lake St. Louis also receives part of the flow of the Ottawa River. From the outlet of Lake St. Louis to Montreal Harbor, a distance of about 13 miles, the fall in the river is about 47 feet, 33 feet of which occur in the Lachine Rapids. During the period 1900-1976, the flow of the St. Lawrence River at Cornwall-Massena has averaged about 237,000 cubic feet per second.

Climate. The climate of the Great Lakes System has four seasons. Average annual temperatures range from 39.0°F on Lake Superior to 48.7°F on Lake Erie. Minimum monthly temperatures generally occur in January or February, while maximum monthly temperatures occur during July.

Monthly average surface air temperatures in January range from 8.7°F at Duluth to 26°F at Chicago, 26.9°F at Detroit, 27.6°F at Cleveland, and 24.5°F at Buffalo. In July, average monthly temperatures range from 65.5°F

at Duluth to 75.6°F at Chicago, 74.4°F at Detroit, 71.5°F at Cleveland, and 69.8°F at Buffalo. Average daily high temperatures for July have ranged from 77.1°F for Duluth, to 84.1°F at Chicago, 83.9°F at Detroit, 82.8°F at Cleveland, and 80.1°F at Buffalo.

Temperatures are influenced by the Great Lakes due to water volume and surface area. This water volume (5,500 cubic miles) and surface area (95,000 square miles) acts as a vast reservoir for the storage and exchange of heat energy with the atmosphere.

This storage and exchange of heat energy significantly moderates the temperature regime of the adjacent land areas. The annual water surface temperature range is half that of the air temperature, and lags the air temperature change by up to three months.

This effect is pronounced during the winter, when lake surface temperatures may be up to 30°F warmer than mean air temperatures, resulting in high lake evaporation. This moisture is carried over the land and results in areas of heavy snowfall downwind of each of the lakes. This effect is reduced when the lake surface becomes ice covered.

Precipitation. Precipitation in the form of rain and snow is the source of water for the Great Lakes. The mean annual precipitation (1900-1977) for Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario basins are 29.7, 31.3, 31.4, 34.0, and 34.6 inches respectively.

Seasonal snowfall over the Great Lakes Basin varies greatly from year to year, and region to region. Annual snowfalls of less than 20 inches are found to the south of the lower lakes, while annual snowfalls exceeding 140 inches occur in pockets east (downwind) and south of Lake Superior and east (downwind) of Lake Ontario. Elevated areas east of Lake Huron experience more than 100 inches during a normal winter. The St. Lawrence River area

has an average annual snowfall of 80 inches. The amount of snowfall may vary from 25 to 40 percent from the mean from year to year.

Water Levels. The levels of the Great Lakes are a result of an integration of all of the hydrologic factors which affect the land and lake surfaces of the basin as well as the hydraulic characteristics of the connecting channels and the St. Lawrence River. Lake level is the characteristic of the lakes which most frequently affects man's use of these waters, since it controls the shoreline use, navigation, and influences the amount of hydroelectric power which can be produced in the connecting channels and outlet river.

The levels of the Great Lakes are not constant. Short-term water level variations are caused by persistent winds and pressure changes, whereas long-term water level variations are caused by changes in lake water volume. Many studies have been made to determine whether the long-term water level variations from high to low and vice versa follow a regular cycle. Other than the usually regular seasonal rise and fall, no evidence for regular long-term cycles has been found.

Ice jams which are formed during the winter in connecting channels, rivers, and bays have historically presented problems concerning short-term variations in water levels.

Ice survey studies, related to the Demonstration activities that were conducted, conclude that the ice cover in the Demonstration Corridor on the St. Lawrence River is naturally unstable due to short-term weather fluctuations. As the ice cover forms on the river in areas with velocities less than 2.25 feet per second, it consolidates, converting the open channel into closed channel similar to a pipe with resultant increases in head loss. However, if the velocities are greater than 2.25 feet per second as they are in many parts of the connecting channels of the Great Lakes, generally a stable ice cover cannot be maintained. As a result, ice

floes which flow through the high velocity areas tend to turn on end or submerge under the head of the stable ice cover. When this happens, an ice jam or hanging dam forms. This results in a constriction in the channel, and the outflow may become seriously reduced. These effects can occur in the outlets of both regulated and unregulated lakes. A technique used to minimize the chance of ice jamming and formation of a hanging dam is to reduce the flow at the onset of ice formation so that the velocities are lowered in the critical sections of the river to allow a consolidated smooth ice cover to form. However, a control or regulating structure must be available in the river in order to utilize this technique.

Ice booms may also be installed across critical sections of a river to reduce flowing ice and subsequent ice jams and, when appropriate, aid in the formation of stable ice cover.

Winter Characteristics - Ice Conditions. In this climatic zone, where the period of freezing temperatures is not normally long enough to cause a lake-wide ice sheet to form, the stages of ice formation and melting sometimes go on simultaneously at different points. The effects of winds, currents, and upwelling upon the ice-cover cause rapid changes, making predictions of ice thickness and distribution difficult.

There are two general types of ice-cover that are formed on the Great Lakes: ice formed by the rapid freezing of surface water in the absence of wind and snow, called sheet ice; and ice made of fused individual ice pieces generally referred to as agglomeratic ice.

Agglomeratic ice usually contains ice of various ages combined with snow masses that have been welded together by new lake ice, and is formed when warm weather allows the breakup of thin, young sheet ice.

Ice-cover on the lakes first occurs in the sheltered bays and harbors and in a narrow fringe along the shoreline. The effects of winds, currents

and upwelling upon the ice-cover causes it to change rapidly because long fetches across the lake surfaces allow the wind and wave forces to attain considerable strength.

As the ice-cover moves and changes, it rafts and forms ridges that in some areas reach a height of 25 feet. Lake ice thickness normally varies from a few inches to 3 feet or more in protected areas.

Under normal climatic conditions, in Lake Superior, the period of ice formation begins in January and continues to maximum accumulation about the last week in March. Its northern location and ice season duration, (approximately 150 days) gives Lake Superior the greatest ice cover of all the Great Lakes. Normally, the ice covers 60 percent of the surface area, but during seasons of severe cold the ice cover may reach 95 percent of the lake surface, and the ice thickness, surface area and ice-season length make the composition of ice cover in Lake Superior resemble that of the Arctic regions.

In Lake Michigan, the period of extensive ice formation begins about the last week of January and continues until around the third week of March. Under normal conditions, the greatest extent of ice-cover occurs in mid-March and covers 40 percent of the lake surface, but during severe winters, ice may cover 80 percent of the surface.

The ice thickness of Lake Michigan varies considerably from 8 to 10 inches at Chicago Harbor to over 30 inches in Little Bay de Noc. In the Straits area, 30 foot ice ridges can be formed and in the open lake drift ice may consolidate to a depth of over seven feet.

Lake Huron has a similar pattern of ice-formation as Lake Michigan. Under normal climatic conditions, 60 percent of the lake becomes ice-covered during mid-March. In a severe winter, the lake may become 80 percent ice-covered. At the time of the greatest ice cover, fast ice

covers the Straits area eastward to Bois Blanc Island, Thunder Bay at Alpena, Michigan, and Saginaw Bay out to Charity Islands. The southern basin, because of the surface current pattern, collects large amounts of drifting ice that can become heavily concentrated at the entrance to the St. Clair River near Port Huron.

Lake Erie, the shallowest of the Great Lakes, reacts rapidly to seasonal temperature changes and is the most thermally unstable of the Great Lakes. Because of this rapid response to air temperature, the lake can accumulate a considerable ice-cover in a short period of time.

Lake Ontario, with its small surface area and great relative depth, reacts slowly to seasonal temperature changes due to its heat storage. This response to climatic change causes Lake Ontario to produce the smallest amount of ice cover of any of the Great Lakes.

An extensive ice-cover formation does not appear until late January and is confined to the east end of the Lake. Under normal conditions, the greatest extent of ice-cover occurs near the middle of March and occupies 15 percent of the Lake surface. Ice covers about 25 percent of the Lake surface during a severe winter. The ice-cover is generally fast ice and the prevailing winds and currents tend to confine and concentrate the ice-cover at the northeastern end of the Lake and the approaches to the St. Lawrence River. The Lake is generally ice-free early in April except for isolated drift ice and ice in some protected bays.

The St. Lawrence River ice-cover usually forms first along the south shore canal between Montreal and Lake St. Louis in early to mid-December and advances up-river to Lake Ontario. Winter conditions usually consist of fast ice which is not generally subjected to breakup from wind or current conditions. Ice thickness in the channel section may average 2 to 3 feet while lake and river ice may only reach a thickness of 1.5 to 2.5 feet.

Floating ice booms are installed annually by the power authorities (Power Authority of the State of New York, Ontario-Hydro of Canada, and Quebec-Hydro of Canada) along the River at the beginning of winter. These booms assist in the stabilization of the ice on the River to reduce the occurrence of ice jams which have an adverse effect on power generation (i.e. reduction in flow in the river). With the consideration of extended season navigation on the River, booms are an impediment to navigation. The ability to transit these booms during winter, without disrupting the stable ice cover, is a very important part of the study.

A survey was conducted for the St. Lawrence River in order to investigate open water pools as a unique glaciological feature contained in the ice cover of the Demonstration Corridor at various stages of a given winter, as well as during winters of varying severity. (St. Lawrence River Glaciology - Pool Characteristics)

Primary data sources consist of air photograph indexes and original air photographs (St. Lawrence Seaway Development Corporation, 1976, 1977, 1978, 1979), aerial ice chart field sheets (Department of Transport, Canada, 1976, 1977, 1978, 1979), and navigation charts (Department of Commerce, NOAA, NOS, 1978 and 1979). In addition, limited field observations made in mid-channel areas during the winter of 1977-78 (Marshall, 1978) and observations of channel areas made from nearshore sites during the winter of 1978-79 were included in this study. Mid channel ice thickness and structure data collected by Canadian surveys were also used.

On the basis of pool characteristics, the section of the St. Lawrence River influenced by possible demonstration voyages were classified into five glaciological reaches. These are: (1) Brockville Narrows, (2) Morristown Point-Ogdensburg, (3) Ogdensburg Ice Boom, (4) Galops Island Ice Boom, and (5) Iroquois Dam.

Three major causes of pool origin are identified.

(1) Upwelling currents: These are caused by deep, rough, river bed conditions, as well as by the presence of islands and shoals in deep and shallower areas;

(2) Currents: Where currents were approximately 3.0 to 5.0 ft./sec., pools were found; and

(3) Placement of engineering structures, e.g., ice booms and dams.

In addition, small scattered pools were observed which existed for varying lengths of time. They originated as interflow areas during the packing of loose floes in mid-channel areas, along shear cracks which developed between channel ice and fast ice, and along major thermal cracks kept open by water upwelling in the crack.

Three major annual patterns of pool geometry with gradations were observed:

(1) Multiple pools characterized by large and small pools concentrated principally along the channel (Brockville Narrows Reach) and also by small, widely scattered pools, non-annual and of variable duration (Morristown Point - Ogdensburg Reach).

(2) Single pools characterized by long, large pools which develop downstream of ice booms and fluctuate slightly in length as ice accumulates at some downstream obstruction (Galop Island Reach and Iroquois Dam Reach).

(3) Intermediate type characterized by a short pool downstream of the ice boom and small, short-duration pools in the stretch of ice cover lying below the pool and above the next downstream obstruction such as an ice boom (Ogdensburg Boom Reach).

Pool duration was affected not only by the relative severity of the winter, but also by river flow manipulation. Pool durations in the five reaches affected by the Demonstration Corridor varied with a given winter by 28 days in a mild winter (1975-76), 20 days in an average winter (1978-79), and six days in a severe winter (1977-78).

The areas of open water for 960 pools throughout the winters of 1978-79, 1977-78, 1976-77, and 1975-76 were measured and are indicated in graphs and tables. The ice characteristics interpreted from air photographs and from limited field work is summarized. An assessment is also made of the factors controlling the stability of ice surrounding the pools and the possible effects of ship traffic. An attempt is made to provide some assessments of the factors controlling pool stability so that these changes can be controlled in order to maintain a habitat which is conducive to the Demonstration Corridor's present bird population.

This study concluded that because of unique ice characteristics (on which little field data are available), hydraulic conditions, and the placement of ice boom and dams, it would be necessary to evaluate ship transit through each pool on an individual basis at various winter stages and during winters of varying severity before impacts could be quantified. Discussion of the stability of pool geometry would be speculation without field data to provide profiles on ice edge and downstream ice characteristics in terms of ice types, degree of rafting, ice field thickness, its structural relationships to fast shore ice, and whether ice broken by ships will remain in the channel or be carried by currents under the ice cover to form hanging dams or ice jams downstream.

Water and Air Quality. Many Federal, state, and local programs exist for the purpose of maintaining or enhancing water quality in the Great Lakes Basin. The Federal programs are primarily the responsibility of the United States Environmental Protection Agency established by Reorganization Plan No. 3, effective 2 December 1970.

Interstate water quality standards have been adopted by all the states in the Great Lakes Basin. In addition to municipal and industrial wastewater control problems, other existing or potential problems involve wastes from watercraft, runoff from urban and rural land (including residues from the application of chemicals), fertilizers and pesticides, heavy metals and other toxic substances, thermal pollution, and the disposal of dredged material. The large concentrations of people and industry in the Great Lakes basin, as well as the concentrations of agriculture in some areas of the Basin, have created water quality problems which urgently require coordinated planning for their solution. The Federal, state, and local efforts to remedy existing water pollution problems and prevent future water quality degradation vary within lake and river basins, because of varying situations and varying availability of required resources and technology.

The adoption of water quality standards by all Great Lakes States faciiitates the coordinated efforts to maintain and enhance water quality. From time to time it may be necessary to modify such standards to reflect changing conditions, changing information, and changing public wishes as to what constitutes best use of all water related resources.

As the growth of population and industry creates additional pressures on water supply and quality for established uses, further emphasis will have to be placed on identifying areas that require advanced waste treatment. In addition to waste treatment problems faced by municipalities and industries, other problems will require continued attention and greater resources for their solution. Examples of such problems are soil erosion and sedimentation, combined sewer overflows, thermal discharges, wastes from water craft, oil pollutiion, organic and toxic contaminants, dredging

activities and non-point source pollution. Plans for the control of non-point sources of pollution are currently being developed under Section 208 of the Clean Water Act (P.L. 92-500, as amended).

Lake Superior Basin Area

The quality of the open waters of Lake Superior exceeds that prescribed in the water quality objectives stated in the Water Quality Agreement of 1972 between the United States and Canada. However, some degraded water quality conditions do exist in near shore areas as a result of point source discharges, tributary inflows and erosion. The major problem areas are Duluth-Superior Harbor, Silver Bay, Thunder Bay and along the southern shore of the lake.

The nearshore water in the Duluth-Superior area is high in fecal coliforms, phosphorus, phenols, copper, suspended solids and turbidity. The major sources of the pollution are the Duluth and Superior Sewage Treatment Plants, U.S. Steel, harbor traffic and the St. Louis and Nemadji Rivers. Eleven sewage treatment plants in the Duluth area were replaced in 1978 by the Western Lake Superior Sanitary District Sewage treatment plant and the Superior sewage treatment plant. Both these plants provide secondary treatment with phosphorus removal and should result in a significant improvement in water quality conditions. The discharge of taconite tailings waste from Reserve Mining Company, into Silver Bay, results in deposits of tailings on the lake bottom and dispersal of asbestiform fibers in the waters of Lake Superior. Tailings presently cover the lake bottom to a depth of at least 0.25cm over a 130 km^2 area. The tailing deposits have resulted in an adverse shift in the benthic community population and structure, reduced aesthetic enjoyment of the water, and violate the 1978 Agreement objective for the settleable and suspended solids. The inhalation of asbestiform fibers, associated with the tailings, has been shown to be associated with asbestosis, respiratory system cancer, gastrointestinal cancer, and pleural and peritoneal

mesothelioma. As a result of extended litigation by the U.S. EPA, the State of Minnesota, and environmental groups, the courts have ruled that the discharge to Lake Superior must cease by April 15, 1980. Reserve is presently constructing an on-land disposal. (Water Quality of the Upper Great Lakes: An IJC Report to the Governments of Canada and the United States, May 1979.) Air quality in the Lake Superior basin is generally excellent. However, some problem areas are present, primarily in the vicinity of large shoreline area industrial complexes.

The general quality of water of the St. Marys River is considered to be of the same excellent quality as Lake Superior water.

Lake Michigan Basin Area

Lake Michigan open waters are of generally high quality, displaying only minor occurrences of degraded water quality that fails to meet the objectives in the Water Quality Agreement of 1972. Three problem areas which have been identified as having significant water quality problems are Milwaukee Harbor, Green Bay, and the Indiana Harbor Ship Canal.

The Milwaukee Harbor area is characterized by high levels of coliforms, Biological Oxygen Demand, low dissolved oxygen and high suspended solids from stormwater and combined sewer overflows. A study is underway for deep tunnel storage and treatment of combined sewage. There is also an ongoing demonstration project for treating overflows by chemical coagulation and activated carbon process. Interceptor sewers have been constructed.

Lower Green Bay has been identified as a polluted area being influenced by the highly industrialized and populous Fox River Valley. Dissolved oxygen levels are low and have been decreasing over the past thirty years and could be responsible for occasional summer and winter fish kills. During warm weather, critical dissolved oxygen conditions are common in the Fox River and extend 2-3 miles into Green Bay. During cold weather,

particularly under ice cover, low oxygen conditions extend about 50 km (30 miles) into the Bay. Phosphorus concentrations are high in the Bay, and, in the vicinity of the Fox River Mouth, large areas of sewage sludge are found in the bottom sediments.

The Indiana Harbor Ship Canal is the main source of pollution in the Calumet area of Lake Michigan. It carries effluents from three municipal treatment plants, East Chicago, Gary and Hammond, and the industrial discharges from Atlantic Richfield, E.I. DuPont, Inland Steel, Union Carbide, United States Steel and Youngstown Sheet and Tube. Some substances which have been identified in the sediments of the Ship Canal in concentrations include phosphorus, fecal coliforms, phenol, cyanide, sulfate, chloride, and ammonia.

Lake Huron Basin and Georgian Bay Areas

The waters in the main body of Lake Huron and Georgian Bay are of good quality and meet the objectives of the Great Lakes Water Quality Agreement of 1972. On the United States side, one problem area, Saginaw Bay, exhibits high concentrations of nutrients, coliform count, and total dissolved solids originating from the Saginaw River System. The biological communities of the Bay are also indicative of poor water quality. The significant discharges to the river and bay are the municipalities of Bay City, Saginaw, Zilwaukee, Midland, Flint and Montrose as well as Dow Chemical and Monitor Sugar Companies. All discharges have remedial programs or are in compliance with a permit schedule. As those schedules are completed, water quality in the river and bay is expected to improve.

Extensive studies and monitoring have been done on the upper Great Lakes' water quality. Details of the studies and monitoring efforts can be found in the IJC report entitled Water Quality of the Upper Great Lakes: An IJC Report to the Governments of Canada and the United States, May 1979.

Lake Erie Basin Area

The water quality of Lake Erie is degraded as compared to the Upper Great Lakes. Lake Erie experiences low dissolved oxygen, high phosphorus concentrations, excessive algal growth and high fecal coliform levels. Many of these problems are caused by point and non-point sources of pollution and from river systems entering the Lake. In particular, the Detroit River is the principal source of phosphorus for Lake Erie. In order to combat this problem, the Detroit Metro sewage treatment plant is undergoing significant upgrading. Approximately 83 percent of the secondary clarifying tanks to be constructed by 1981 are completed. During the period from 1968 to 1977 a significant decrease in phosphorus loading to the Detroit River occurred, and a further reduction can be expected as the Detroit plant attempts to meet its 1980 NPDES requirements. Other improvements in water quality can be expected due to the current upgrading of county sewage treatment facilities.

Lake Ontario Basin Area

The open waters of Lake Ontario are showing some of the signs of degradation that are evident in Lake Erie. While not as severe as the upstream lake, the signs are danger signals that will bear close observation in the future. Surveys in 1974 indicated a larger number of locations with dissolved oxygen levels lower than those in 1970. The dissolved oxygen content at many of these locations was less than the Water Quality Agreement objective of 6 mg/l. The total dissolved solids measurements in the lake exceeds the objective level of 200 mg/l.

The St. Lawrence River has a well developed calcium carbonate buffering system and can be classified as a hardwater river. Low levels of phosphorus during the summer months indicate that this element is most likely the primary nutrient controlling production in this river system.

Dissolved oxygen levels were not depressed in bottom waters at any sampling sites.

In the Ogdensburg, New York area, treatment facilities are under construction at Diamond International Corporation to prevent water discoloration. Secondary treatment and phosphorus removal for the City of Ogdensburg are to be completed in 1978.

At Massena, New York, the Aluminum Company of America is in the final stages of converting to a dry processing operation to reduce fluoride and cyanide discharges into the lower Grass River.

Ontario industries along the river show little effect of waste discharges beyond the zone of initial mixing and are not considered to be contributing to problem areas along the St. Lawrence River. A surveillance program was conducted in 1977 by the Canadian Department of Fisheries and the Environment (DFE), consisting of sampling at 68 stations from Kingston to Cornwall, Ontario, on 6 cruises. Biophysical-chemical and toxic substances, water and microbiological sampling is planned. The New York State Department of Environmetnal Conservation will continue to perform monthly physical, chemical and bacteriological baseline sampling on the St. Lawrence River. The program includes the collection of fin fish for analysis of persistent organic toxicants and a macroinvertebrate species density and diversity survey for the New York State reach of the St. Lawrence River.

A summary of areas in the upper and lower lakes not meeting water quality objectives according to the Water Quality Agreement of 1972 is shown in Table I-1 and I-2. U.S. regulations of the discharge of black water from commercial vessels are based upon the Federal Water Pollution Control Act of 1972 (P.L. 92-500). In addition to specifying treated

effluent standards and a schedule of compliance, P.L. 92-500 grants individual States the right to petition the EPA for more stringent standards or complete prohibition of vessel sewage discharge.

In 1977, the Clean Water Act (P.L. 95-217) amended P.L. 92-500. These amendments, pertaining to commercial vessels on the Great Lakes, involve new definitions of waste waters which must receive treatment.

Topography and Geology. The basins occupied by the Great Lakes-St. Lawrence River were created during the Wisconsinan glaciation in the Pleistocene Epoch. The Great Lakes, with their outlets and existing lake levels date back less than 3,000 years, with the subsequent processes of stream and shoreline erosion only making slight changes in the original topography.

Prior to the Pleistocene or latest Ice Age of earth history, the Great Lakes were nonexistent, the area being traversed by the well-drained valleys and divides of several large rivers. When the continental ice cap developed over Canada, it spread southward, covering what is now the Great Lakes-St. Lawrence River Basin. Bedrock was eroded and the debris entrained in the ice mass. Then, as the ice sheet retreated northward, this entrained debris was released and vast irregular deposits of overburden were laid down. The topography was changed with parts of the major preglacial valleys being deepened or filled by glacial action; thus forming the Basins of the five Great Lakes.

Table I-1

AREAS IN THE LOWER LAKES NOT MEETING WATER QUALITY OBJECTIVES

Lake Erie Basin	Lake Ontario Basin
Cleveland Area	Niagara River
Toledo Area	Twelve Mile Creek
Sandusky River	Hamilton Harbor
Huron River	Toronto Harbor
Vermilion River	Oshawa Creek
Rocky River	Etobicoke Humber River
Ashtabula River	Duffin Creek
Conneaut Creek	Don River
Chagrin River	Highland Creek
Portage River	Moira River
Black River	Port Hope Harbor
Grand River, Ontario	Bay of Quinte
Detroit River	Buffalo River
St. Clair River	Tonawanda Creek
Thames River	Niagara Beach
Sydenham River	Olcott Harbor
Western Lake Erie	Rochester Harbor Area
Pelee Island	Oswego Harbor Area
Wheatley Harbor	Black River
Big Otter Creek	St. Lawrence River
Big Creek and Lynn River	
Kettle Creek	
Grand River, Ohio	
Long Point Bay	
Fredonia Area	
Westfield Area	

NOTE: Except for connecting channels, problem areas identified with rivers refer to areas in the boundary waters at the mouth of the river.

Table 1-2*

AREAS IN THE UPPER LAKES NOT MEETING WATER QUALITY OBJECTIVES

Lake Superior Basin	Lake Michigan Basin
Thunder Bay Harbor	Green Bay Area
Marathon-Peninsula Harbor	Milwaukee Harbor
Jackfish Bay	Indiana Harbor Ship Channel and Inner Harbor Basin
Nipigon Bay	
Silver Bay	
St. Louis River	**Lake Huron Basin**
Duluth Harbor, Minn.	Saginaw Bay
Duluth Harbor, Wis.	St. Marys River
Area from Duluth to Sand Point	Penetang Bay
Chequamegan Bay	Midland Bay
Area From Chequamegan Point to Montreal River	North Channel (near Spanish River)
	Serpent River
Ontonagon	McCurry Lake Outlet
	Maitland River
	Douglas Point

NOTE: Except for connecting channels, problem areas identified with rivers refer to areas in the boundary waters at the mouth of the river.

*Great Lakes Water Quality 1974 Annual Report to the International Joint Commission, Great Lakes Water Quality Board, July 1975; p. 109, 111.

During the final northward recession of the ice front, there was pooling of the meltwaters which resulted in gradually enlarging bodies of lake water. As the ice border receded, the pattern and the levels of these lakes was changed as new outlets were formed. Concurrent with the shrinking of the ice mass, there was differential uplift of the earth surface in the region.

The outlets of Lakes Superior and Erie are controlled by bedrock at shallow depths at Sault Ste. Marie and the Niagara River below Buffalo, while the Lake Huron outlet control still remains in glacial overburden located below the St. Clair River.

The Great Lakes basin is underlain almost entirely by a thick succession of sedimentary rocks. The major structures include the large Michigan basin and a long, narrow structural platform, extending from Indiana to the St. Lawrence Valley. Crystalline rocks extrude in the western Lake Superior and Adirondack regions and form a buried structural high separating the sedimentary basin and platform structures.

Glacial and alluvial deposits cover the bedrock. These deposits are as much as 1,100 feet thick, with the thickest deposits generally occurring in Michigan and locally in buried bedrock valleys of New York and Wisconsin. The deposits are thin or nonexistent on bedrock surfaces located in the southern part of the Basin and on the bedrock "highs" of Minnesota, New York, and Wisconsin. The deposits range in composition from clay and silt, through sand and gravel, to boulders which are well sorted, or a heterogeneous mixture. The clay and silt deposits represent the former extent of lakes formed during deglaciation and generally border the present Great Lakes. The sand and gravel deposits were formed by glacial meltwater streams that sorted the glacial materials.

The land tributary to the Great Lakes is included within the areas of two physiographic regions: The Laurentian Uplands and the Central Lowlands. Areas of the Great Lakes basin north and west of Lake Superior and north of Lake Huron are in the Laurentian Uplands and are dominated by hills, a few low mountains with summit elevations up to about 1,700 feet above sea level, and many lakes and swamps. In general, the bedrock has a

shallow overburden. The region is ot cultivated to any extent and much of it is forested. In the Central Lowlands portion of the Basin, land is gently rolling to somewhat flat.

The Great Lakes basin has a range of elevation from about 1,980 feet above sea level at Mt. Curwood in the Huron Montains south of Lake Superior to 152 feet above sea level at Cornwall, Ontario near the International Boundary.

Soils. The Great Lakes basin has large areas of relatively flat land with high water tables and fine-textured soils. The land areas of much of the Great Lakes basin were formed as glaciers receded to the north. During this final northward recession of the ice sheet, there was ponding of melt waters between the ice and the exposed glacial deposits. These glacial lakes occurred at several different elevations. At each lake level, sediments were deposited. Patterns and levels of those lakes were repeatedly changed as new lower outlets were uncovered. This left extensive, relatively flat areas with fine textured lake bed deposits.

These soils of glacial origin include the Iron River and Gogebic soils in Minnesota, Wisconsin, and the upper Peninsula of Michigan. Also in this area are the Ontonagon and Trenary soils which are in calcareous clays and loams. The Rubicon, AuGres, and Roscommon soils which occupy areas in Wisconsin and much of Michigan, are level to rolling, well-drained to poorly-drained sands. Southern Michigan, Indiana, western Ohio, and eastern Wisconsin include soils in rolling, calcareous glacial till and sand outwash materials. The Wooster-Mahoning soils occur in rolling, acid glacial till in eastern Ohio and Pennsylvania. The Ontario and Lordstown soils occupy much of western New York. The Ontario soils are in deep, calcareous glacial till and the Lordstown soils are in thin, acid glacial till over sandstone and shale. Other areas of upper New York have Gloucester soils with rough, stony land prevalent in the Adirondack Mountains.

Erosion, Sedimentation and Shore Use. Shorelands are the focus of development in the Great Lakes Region for waterborne commerce, water supply, and recreation. Primary factors determining the type of shoreland use and development in a given area are geographical location, accessibility, ownership, shore type, and historical development.

Structural development (industrial, commercial, and permanent residential) is predominant along lower Lakes Michigan and Huron, Lake Erie, and Lake Ontario. Industrial and commercial development is concentrated primarily in urban areas. Seasonal residential development is located primarily along the northern shorelands of northern Michigan, Wisconsin, and Minnesota, away from the metropolitan concentrations of the lower Great Lakes.

Forested shorelands are almost exclusively confined to the northern areas of Michigan, Wisconsin, and Minnesota. Large tracts of wildlife and game preserves are located along many of the isolated lakeshore areas of Michigan, Wisconsin, and Minnesota and along the western Lake Erie shorelands of Ohio and Michigan. Both public and private interests administer these areas to provide habitat and cover for wildlife and to promote better hunting opportunities in the Great Lakes Region.

Located along the shores of the Great Lakes are the largest recreational areas in the Great Lakes Region, three national lakeshore parks, 67 State parks, and numerous local parks. Lake Michigan has approximately one-half of all designated recreation mileage along the Great Lakes shorelands. Lake Huron has the smallest number of miles of recreation shorelands of any of the Great Lakes.

Shore erosion is a natural occurrence along the Great Lakes shoreland. Major causes of this shore erosion on the Great Lakes include underground water seepage, frost and ice action, surface water runoff, and wave action. Wind generated wave action causes the greatest erosion damage. Wave action works directly on the beach or at the toe of the bluffs eroding away clay,

silt, sand, and gravel. The intensity of damage caused by wave action varies with the magnitude of the waves generated, the elevation of the undisturbed lake level, the temporary increase in that level generated by wind or barometric pressure gradient, and the erodibility and exposure of the shorelands.

Shoreland damages can be reduced by providing advice and assistance to owners of shore property on proper protection and through implementation of new lake level regulation plans. The only management techniques applicable to shoreland erosion problems are acquisition and regulatory controls. These measures will not reduce future losses of land due to erosion, but they can reduce or eliminate costly damage to structures built in the future. The effects or shore erosion and damage to shore structures on the connecting channels, caused by winter navigation, are an important part of this study.

Coastal Zone Management

Due to intense pressure on coastal areas of the United States, Congress passed the Coastal Zone Management Act of 1972. The Act, as amended in 1976, affirm a national interest in the effective protection and development of the coastal zone by providing assistance and encouragement to coastal states to develop and implement rational programs for managing coastal zone.

The eight Great Lakes States are in various phases of development and/or implementation of a coastal zone management. The following is a brief synopsis of the accomplishments, so far, in each of these Great Lakes States:

ILLINOIS:

Has 60 miles of shoreline, most in or near Chicago, on Lake Michigan.

Completed coastal program document and sought necessary state legislation in 1978, but the legislation was not passed, and Federal funding was terminated as a result. Several programs started by the coastal program have continued with State funds, and legislation has been introduced for the 1979-80 session.

In developing its Coastal Zone Management Program, Illinois:

- developed a comprehensive erosion program, by mapping erosion prone areas, gathering baseline data on the coast and recommending guidelines for resolving erosion problems.

- conducted marina siting studies that examined the need, possible locations, design, and environmental impact of marinas.

- provided initial funds for a project to increase traffic through the under-used Transoceanic Terminal/Iroquois Landing.

- identified reefs where trout could spawn and stocked those areas to encourage natural regeneration of the trout fishery.

- funded City of Chicago lakefront planning efforts.

INDIANA:

Has 60 miles of shoreline on Lake Michigan where both steel industries and valuable dune ecosystems are located.

In its third year of activity, the Indiana coastal program is releasing the discussion draft of its proposed program for public review this month.

In planning Coastal Zone Management Programs, Indiana:

- conducted wetlands and natural areas inventories identifying unique natural features.

- identified and documented land fills on the coast.

- conducted a survey of bank fishing and boat launching needs.

MICHIGAN:

The state with the most Great Lakes shoreline, Michigan has 3,200 miles of coast. It borders on Lakes Huron and Michigan.

Program approved by the Federal Government in August, 1978, now implementing projects included in the program.

In the development of its Coastal Zone Management Program, Michigan:

- provided local areas with methods and costs of shore protection alternatives.

- funded a precedent setting wetlands study that evaluated the physical and biological attributes of wetlands.

- identified high risk erosion and wetlands areas and funded the administration of state laws that regulate these locations.

- begin a number of local projects: Detroit fishing facilities, waterfront development and restoration of a historic site along the St. Marys River.

- began identifying Great Lakes fish spawning sites to begin a return to natural trout reproduction in the lake.

MINNESOTA:

Has 175 miles of Lake Superior Shoreline, most of which is rural and undeveloped while the rest is an urban port complex.

Coastal program is now suspended, and State action is needed to reinstate it.

In planning its Coastal Zone Management Program, Minnesota:

- conducted the first detailed soil survey for the coastal areas.

- inventoried all historic, natural areas, beach areas, and transportation routes.

- compiled a data atlas with land use, soil associations, water orientation, and forest cover.

- accelerated improvements on the main transportation route in the coastal zone.

- completed a Duluth-Superior Harbor study which established the direction for future use and development of the harbor. The plan dealt with dredge spoil disposal, industrial development, recreation, and land use.

NEW YORK:

Has 560 miles of shoreline on Lakes Erie and Ontario and 2,600 miles on the Atlantic seaboard.

In planning its Coastal Zone Management Program, New York:

- sent legislation to state government and anticipate program approval in 1980 in the fourth year of program development

- held a workshop on energy facility siting to solicit public opinions on selecting power plant locations.

- put representatives of shoreline residents on the board that regulates the water level of Lake Ontario and the St. Lawrence River.

- funded development of walkway through part of the Buffalo waterfront.

- inventoried erosion hazard areas and wetlands and provided the data to local planners.

OHIO:

Has 190 miles of shoreline, much of it devoted to port and shipbuilding activities and other industrial development.

Ohio is now seeking state legislation and anticipates coastal program approval in mid 1980.

In planning its Coastal Zone Management Program, Ohio:

- created the Coastal Zone Management section of the Ohio Department of Natural Resources.

- studied erosion and flood hazards, mapped recession rates for the entire shoreline, and drafted policies to solve erosion and flood problems.

- inventoried the Ohio coastline and mapped historical/cultural sites, prime agricultural lands, fish and wildlife habitats, wetlands, land use in the coastal region and land ownership in special coastal areas.

- coordinated the activities of different agencies dealing with the coastal region.

PENNSYLVANIA:

Has 48 miles of shoreline on Lake Erie, with 60 on the Delaware River/Atlantic. Pennsylvania is now moving to complete its program and receive approval before the deadline in 1980.

In planning its Coastal Zone Management Program, Pennsylvania:

- drafted state legislation on wetlands and coastal dredging and construction.

- developed a planning procedure for shore front access, energy facility siting, and erosion prevention.

- promoted "bluff set back" legislation in six Lake Erie communities.

WISCONSIN:

With 620 miles of shoreline on Lakes Michigan and Superior, Wisconsin was the first state in the Great Lakes region and fifth in the nation to obtain Federal approval of its coastal program. Now in the program implementation phase, it has applied for continued funds.

In the development of its Coastal Zone Management Program, Wisconsin:

- studied environmental and economic implications of existing State and Federal dredging and dredge spoil regulations.

- reduced the routine waiting time for dredge permits from 60 to 16 days and brought more consistency to the application of regulations.

- studied the technical aspects of erosion problems; prepared policy alternatives to prevent and repair erosion damage; and developed a permit process, guidelines, and setback provisions for construction in hazard areas.

- conducted an inventory of structures, land use, natural areas, and historic sites along the Wisconsin coast.

- assessed fish stocks and began to identify reefs and shoals where fish breed as part of a Great Lakes effort to stabilize sports and commercial fish habitats.

- completed the first management plan for the future development of Superior-Duluth harbor.

- funded a number of local waterfront recreation projects.

Since adequate environmental baseline data is not presently available, consistency with individual States' CZM programs cannot be determined at this time. However, as the winter navigation study proceeds, each of the eight states would be coordinated with, to insure that conflicts with the coastal zone policies and land use programs are avoided.

Fisheries Resources. The Great Lakes Basin contains more than 237 kinds of fish (species and sub-species), which represent most of the important families of fresh water fishes in North America. Most of these species are indigenous to the Basin, having entered the lakes during the last glaciation (the Wisconsin) period. During the development of the Great Lakes System, there existed a water connection between the lakes and the following drainages: Hudson Bay and Upper Mississippi; the Ohio and

Middle Mississippi Rivers; and the Mohawk, Hudson, and Susquehanna Rivers. In addition, exotic species are present, having been either purposely or inadvertently introduced by man. These introductions, along with past fishery management practices, have led to significant changes in the fisheries resources of the Basin. Such an example is that of the sea lamprey which entered the Upper Great Lakes through the Welland Canal. The sea lamprey has had one of the largest impacts on the fisheries of the upper lakes.

Commercial fishing within the Great Lakes has been an important resource for over a century, however it has been declining over the years. Prior to 1950, eleven species contributed significantly to the U.S. Great Lakes commercial fishery: lake sturgeon, lake trout, lake herring, pike, chubs, lake whitefish, carp, suckers, catfish, yellow perch and walleye. Of these, only the last seven have played a substantial role in the commercial fishery of the last two decades. The elimination of the first four species from the commercial fishery was due to: reduction of stock due to increased mortality from sea lamprey predation, increased competitive pressures caused by the introduction of smelt and alewives, and overfishing. These species still remain as considerations in a future restored fishery. Four other species, northern pike, bullhead, sheeps-head and quillback, have contributed to the commercial fishery to the present, but their total combined catch has represented only 1.56 percent of the total over the last 20 years. Three introduced or invading species, the smelt, alewife and sea lamprey, have become significant to the fishery over the last twenty years; and four others, the coho, chinook and kokanee salmon and the splake may play an important part in the future fishery.

Sportfishing within the Great Lakes Basin was estimated in 1970 at 81.2 million angler-days effort. Of this amount over 16 million angler-days of effort were spent on the Great Lakes. By 1980, sport fishing activity is expected to increase to an estimated 106 million angler days, with the Great Lakes demand estimated at over 27 million angler days. Major species

sought are lake trout, yellow perch, coho salmon, rainbow trout, brown trout, chinook salmon, walleye, northern pike, smelt, herring, channel catfish, muskellunge, small and largemouth bass, white bass, Atlantic salmon, suckers, and carp.

Lake Superior and St. Marys River and Rapids. The earliest fisheries on Lake Superior were for lake trout and whitefish, these species dominating the commercial take prior to the start of the present century. Subsequently, lake herring and, to a lesser extent, chubs, became more important, while whitefish and sturgeon declined; but otherwise there was little change in the fishery until the 1950's.

The invasion of Lake Superior by sea lamprey in the 1940's triggered the catastrophic decline in the lake trout fishery and led to secondary events which now determine the composition and yield of fish stocks. Hatchery-reared lake trout now form more than 90 percent of the trout population rising to levels comparable in some areas to those of pre-lamprey days. Natural reproduction has not yet reached the point where the trout are self-sustaining.

Future success of the sport and commercial fisheries for salmon and trout appears to depend on the degree to which lamprey can be controlled, the ability of lake trout to become self-sustaining, and the future policies of management agencies with regard to plantings and commercial harvesting.

The following species are known to be available to the angler in the St. Marys River and Rapids:

northern pike	Esox lucius
round whitefish	Proscopium cylindraceum
rainbow trout	Salmo gairdneri
brook trout	Salvelinus fontinalis

white sucker	Catastomus commersoni
lake whitefish	Coregonus clupeaformis
cisco	Coregonus spp.
carp	Cyprinus carpio
lake sturgeon	Acipenser fulvescens
walleye pike	Stizostedion vitreum
chinook salmon	Oncorhynchus tshawytscha
yellow perch	Perca flavescens
northern rock bass	Ambloplites rupestris

Historically, the St. Marys River Rapids provided a valuable sport fishery for rainbow trout. Today, the fishery is still important although reduced somewhat from its former quality. This reduction has been caused partially by a reduction in the area of the rapids and the manipulation of water flows and levels within the area of the rapids.

Lake Michigan. Historically, the fishery in Lake Michigan was based on lake trout, herring and whitefish; these species dominated the catches until the mid-1940's when the effects of sea lamprey predation became noticeable. Although the average weight of the total catch (about 16 million pounds annually) remained virtually unchanged until the present, its species composition, and hence its landed value, has changed drastically. Nearly all of the traditional species (including lake trout, herring, chub and yellow perch) have declined and been replaced by low-value species, such as carp and alewife. Only recently have introductions of hatchery-reared lake trout and Pacific salmon contributed significantly to the rapidly developing sport fishery.

In the future, continued introductions of various trout and salmon species will play an increasing role in maintaining the sport fishery, while strict commercial fishing regulations, together with control of the sea lamprey, should help to rehabilitate a commercial fishery for whitefish and chubs.

The species of sport fish ranked in order of importance for the past, present and future are as follows:

Sport Fisheries

PAST	PRESENT	FUTURE
Smallmouth bass	Coho salmon	Lake trout
Walleye	Lake trout	Coho salmon
Yellow perch	Steelhead	Yellow perch
Lake trout	Chinook salmon	Smallmouth bass
Northern pike	Smallmouth bass	Rainbow trout
Herring	Yellow perch	Brown trout
	Northern pike	Chinook salmon
	Walleye	Northern pike
	Brown trout	Atlantic salmon
	Smelt	

Lake Huron. Lake Huron has a long history of use by anglers and commercial fishermen, leading to the present. Both interests are expected to continue to share the use of the resources. A recreational fishery for lake trout is increasing since lamprey years, due to control of lamprey and restocking efforts. The inshore sport fishery concentrates on such species as rainbow trout, bass, pike, walleye and perch. The biological base for these inshore activities remains relatively strong in most areas. The future is expected to bring the return of a deepwater angling fishery based on splake and various species of trout and salmon. At the same time, angling effort in the more protected bay and island areas is certain to intensify.

Lake St. Clair, St. Clair River and Detroit River. With a population in excess of 3 million living adjacent to the Michigan shoreline (Detroit,

Mt. Clemens and vicinities), and over 1/2 million people in the Ontario vicinity (Windsor, Chatham, Sarnia and vicinity), the sport fishery on Lake St. Clair, the St. Clair River and the Detroit River is one of the largest in the Great Lakes area. Although fishing activity and harvest were curtailed significantly in 1970 after the discovery of mercury in fish (in the summer of 1971) angling pressure and harvest appeared to be returning to normal. Important sport species taken include perch, walleye, smallmouth and largemouth bass, panfish and muskellunge. In Ontario waters of the lake, conservative estimates of fishing activity are 200,000 angler-days and harvest of about 640,000 pounds.

Lake Erie and Upper Niagara River. Fish distribution and composition in Lake Erie differ from other Great Lakes primarily because of adverse environmental factors. The Lake Erie fish ecosystem has undergone radical changes due to environmental change and high utilization.

Sturgeon virtually disappeared from Lake Erie around the turn of the century. Whitefish and cisco, once abundant Lake Erie species, have declined sharply.

In the past, the sport fishery of the area was carried on mostly from shore installations and in bays. With present day sportsmen acquiring great numbers of improved equipment, angling methods are changing.

Sport fishing has been important in the development of resorts and vacation areas within the area. More than half a million anglers annually spend over 8 million angler days sport fishing in the U.S. waters of Lake Erie proper. These anglers harvested an estimated 18 million fish.

Lake Ontario - St. Lawrence River. One of the most valuable biotic resources of eastern Lake Ontario and St. Lawrence River is the area's fishery. Fishing has been and remains a major part of the region's primary industry--tourism.

The importance of the sport fishery of the area well exceeds that of the commercial fishery. Commercial fisheries of the past concentrated on such valued species as lake trout, whitefish, herring and ciscoes. The stocks of these fish have now become depleted below a commercial level.

In contrast the sport fishery has risen in importance providing a multimillion dollar resource.

A technical report (1972) on fisheries resources dependent upon tributaries, wetlands and bays in St. Lawrence and Jefferson Counties identified eleven warm water species as major contributors to the economy of the region: smallmouth bass, northern pike, yellow perch, brown bullhead, muskellunge, rock bass, white perch, white bass, pumpkinseed, largemouth bass and walleye.

In 1976 the U.S. Army Corps of Engineers initiated, under the Demonstration Program for Navigation Season Extension, a preliminary base condition fisheries study on the St. Lawrence River. These study efforts were conducted through the U.S. Fish and Wildlife Service. The last prior comprehensive biological survey was conducted in 1930-31. Therefore, the 1976 study has provided a new starting place for long term systems study of the aquatic resources of the river.

A brief summary of selected elements of the St. Lawrence Ecological Studies: Biological Characteristics, 1976 (U.S. Dept. of Interior, Fish and Wildlife Service, Cortland, N.Y.) follows.

Larval fishes and ichthyoplankton studies indicated that sampling techniques for larval fishes in dense vegetaion areas are lacking and new methods must be developed. Weedy areas provide both food and protection for young fish, and being relatively shallow areas, they are more subject to effects from environmental changes.

A preliminary study on the feeding ecology of the St. Lawrence's fishes indicated that aquatic invertebrates were the most important food items of fish under 25 inches in length.

Preliminary data for species composition and distribution along the river were gathered. Ninety-nine (99) species of fish have been reported in the literature from the International section of the river, however, only 67 species were collected in the 1976 study.

Wildlife Resources. There are approximately 220 kinds of birds and 78 kinds of mammals in the Great Lakes Basin. Upland game birds found in the Basin include ring-necked pheasants, ruffed grouse, quail, and turkey. Waterfowl include several species of geese and many species of ducks. Typical shore and marsh birds include bitterns, rails, herons, loons, red-winged blackbirds, gulls, and terns. Common non-game birds include hawks, owls and many species of songbirds. Endangered bird species in the basin include the American peregrine falcon, arctic peregrine falcon, Kirtland's warbler and bald eagle.

Important game animals for which over 24 million man-days hunting was spent within the Basin, includes the white-tailed deer, black bear, cottontail and snowshoe rabbit, squirrel, ring-necked pheasant, ruffed grouse, quail, geese and migratory waterfowl. Important fur animals in the Basin are muskrat, beaver, otter, mink, martin, fisher, racoon, grey and red foxes, bobcat, skunk, and coyote. Federal Endangered/Threatened species of the region include the gray wolf (timber wolf) and the bald eagle.

The waters of the Great Lakes and adjacent basin areas provide a flyway route for millions of North American waterfowl and breeding territories for lesser numbers of the twenty-seven species using the Great Lakes Basin. While waterfowl are distributed generally throughout the basin, there are

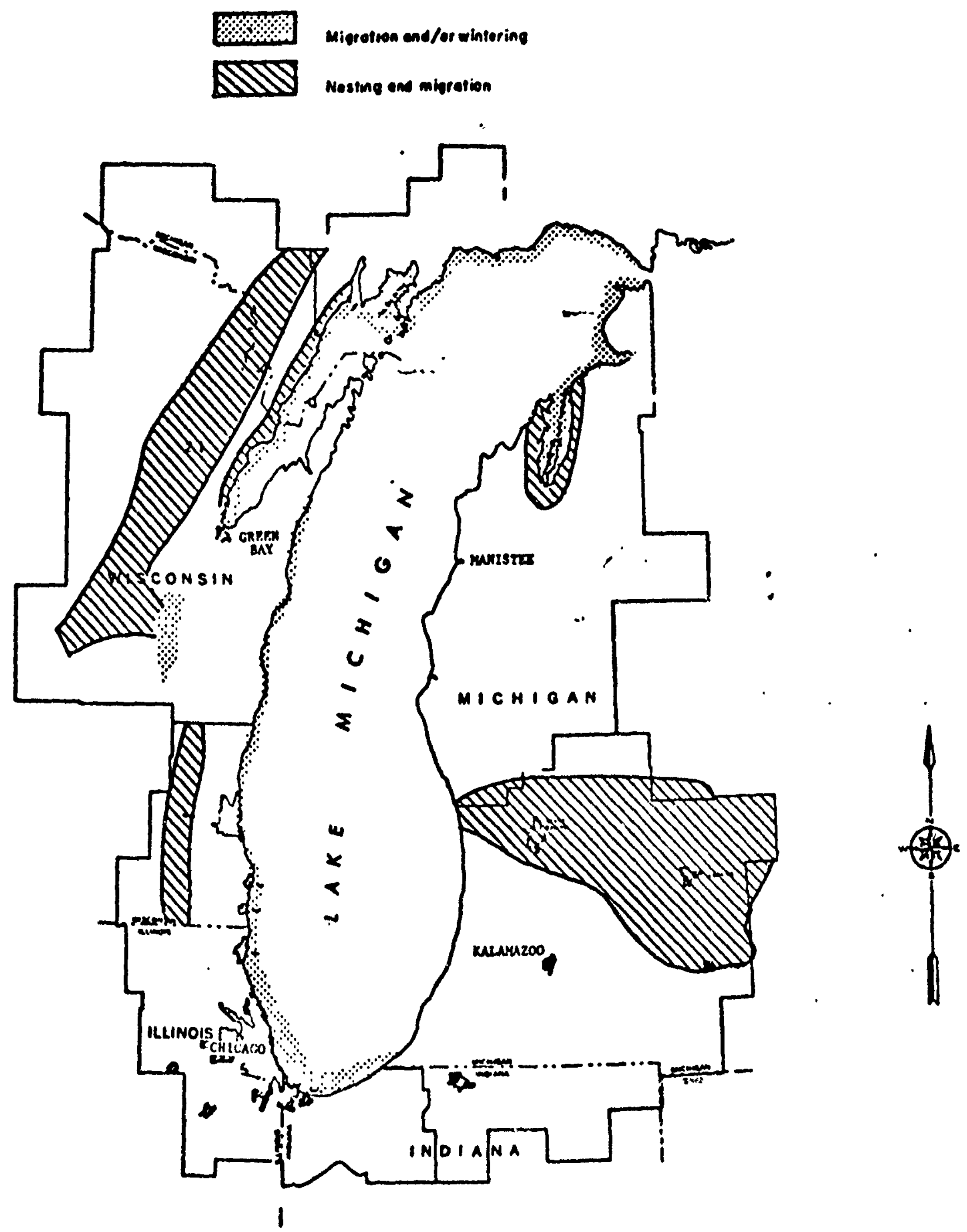
major concentration areas serving the migrant and breeding ducks, geese, coots, and swans. These concentration areas include Taquamegon Bay, Lake Superior; Green Bay and Bay de Noc, Lake Michigan; Saginaw Bay, Lake Huron; Lake St. Clair; St. Marys River; Point Pelee Marsh, Rondeau Bay, Long Point Bay, and the western end of Lake Erie; Niagara River; and the Thousand Island area in the St. Lawrence River. In addition, many marshes and shallow bays provide secondary concentration areas. Pages F-I-48 through F-I-52 show primary waterfowl use areas.

The shallow waters, shoreline marshes, and wetland meadows are important nesting, resting, and feeding areas. During migrations, the deeper semi-protected waters are heavily used by diving ducks. Consequently, most areas of the lakes are important to waterfowl.

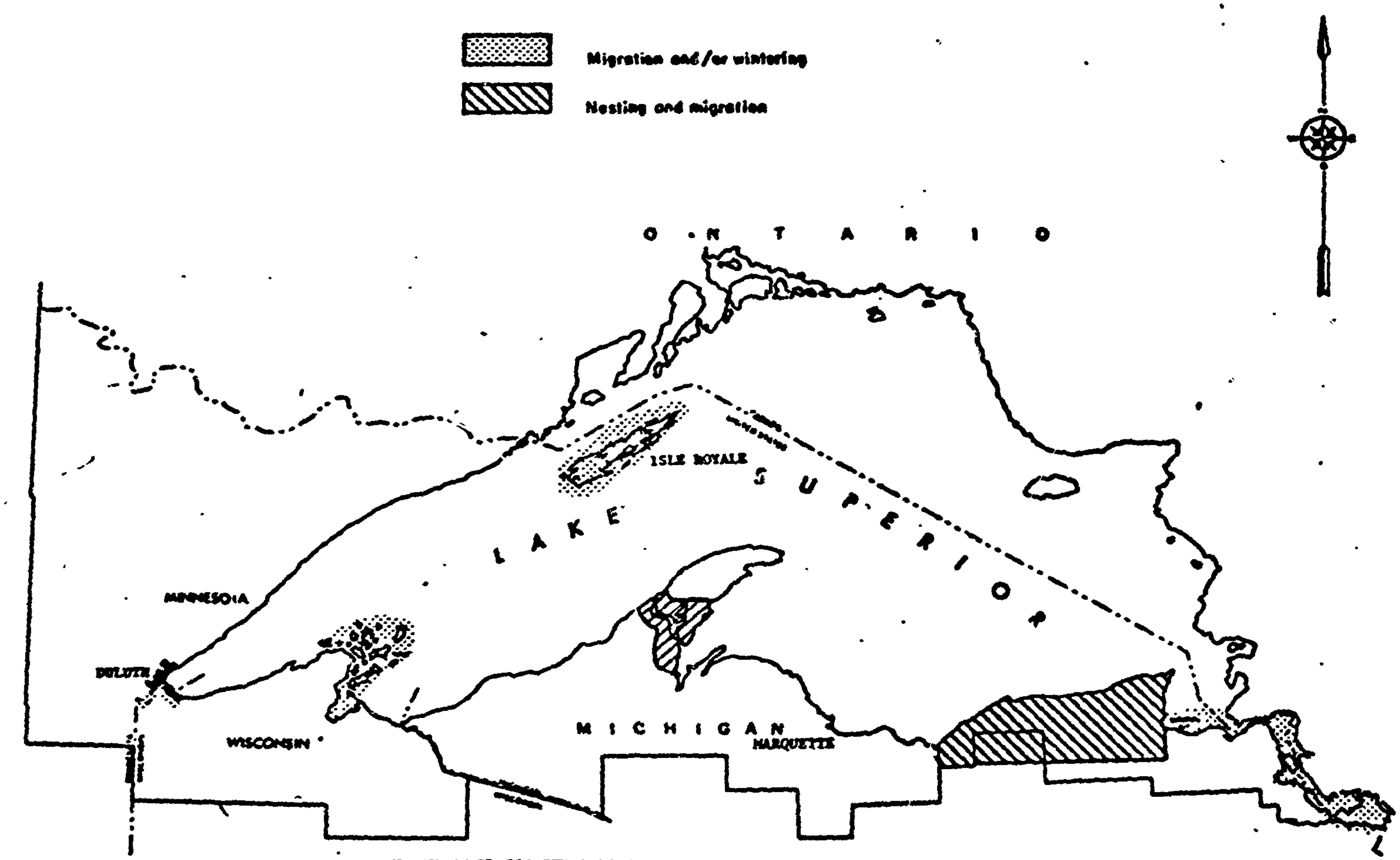
Available waterfowl population surveys indicate that more than one million ducks use Lake St. Clair and western Lake Erie during the peak of migrations. These ducks, primarily diving ducks such as canvasbacks and redheads, are attracted there by the extensive beds of submerged aquatic plants prevelent in both of these areas. Pages F-I-53 through F-I-56 show the migration routes of various waterfowl in the Great Lakes/St. Lawrence Seaway.

The marshes of Lakes Erie, St. Clair, and Huron are also used during migration by approximately two-thirds of North America's 100,000 Whistling Swans.

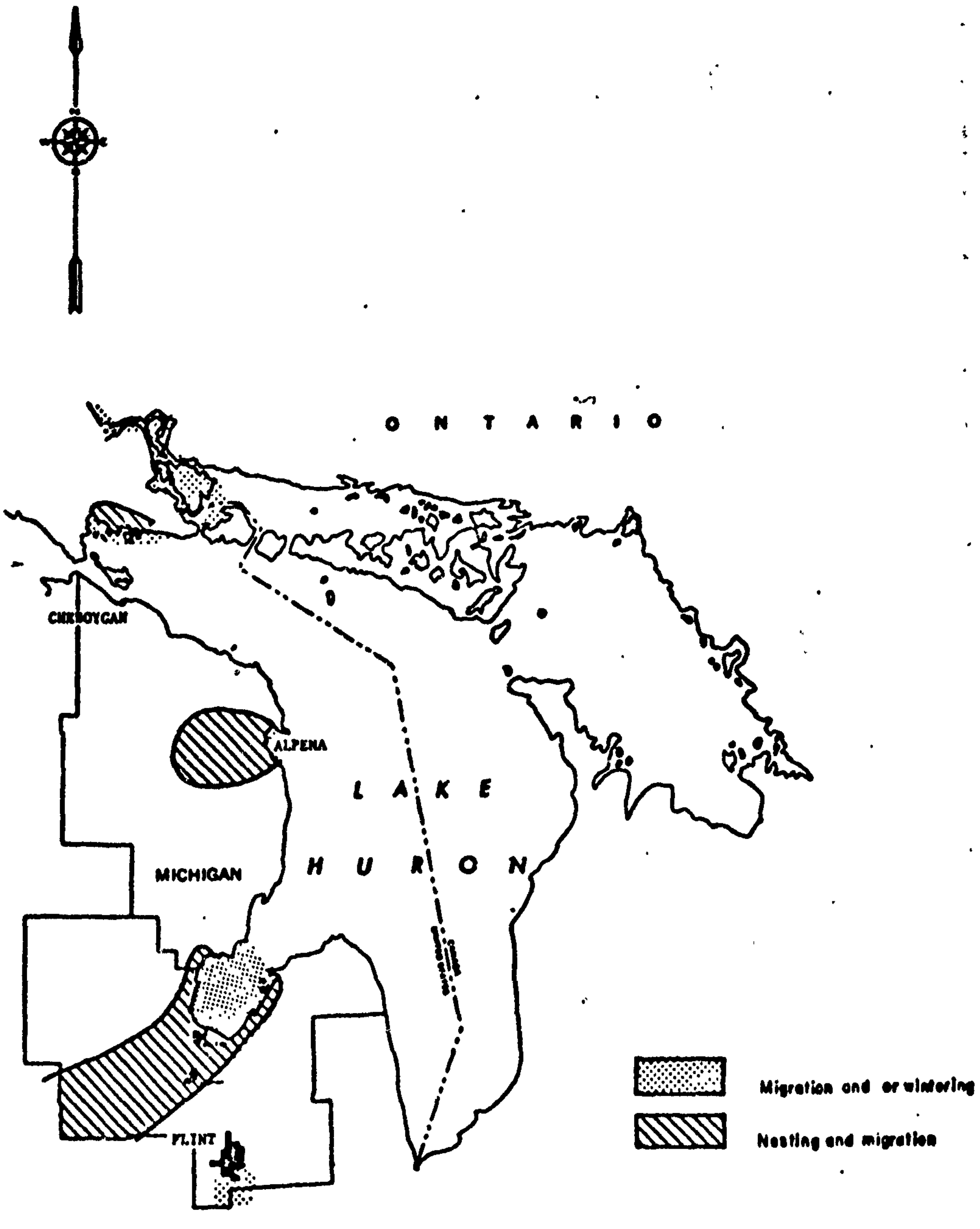
In addition to waterfowl, the marshes support large numbers of commercially valuable furbearers; namely, muskrats and mink, while bordering swamp and water-logged shrub swamps support lesser numbers of beaver and otter. Muskrats are the most common and, economically, the most important furbearer. The overall population of muskrats can vary drastically over a period of years due to epidemic disease, habitat changes, and reproductive rates. Mink populations exhibit a similar though



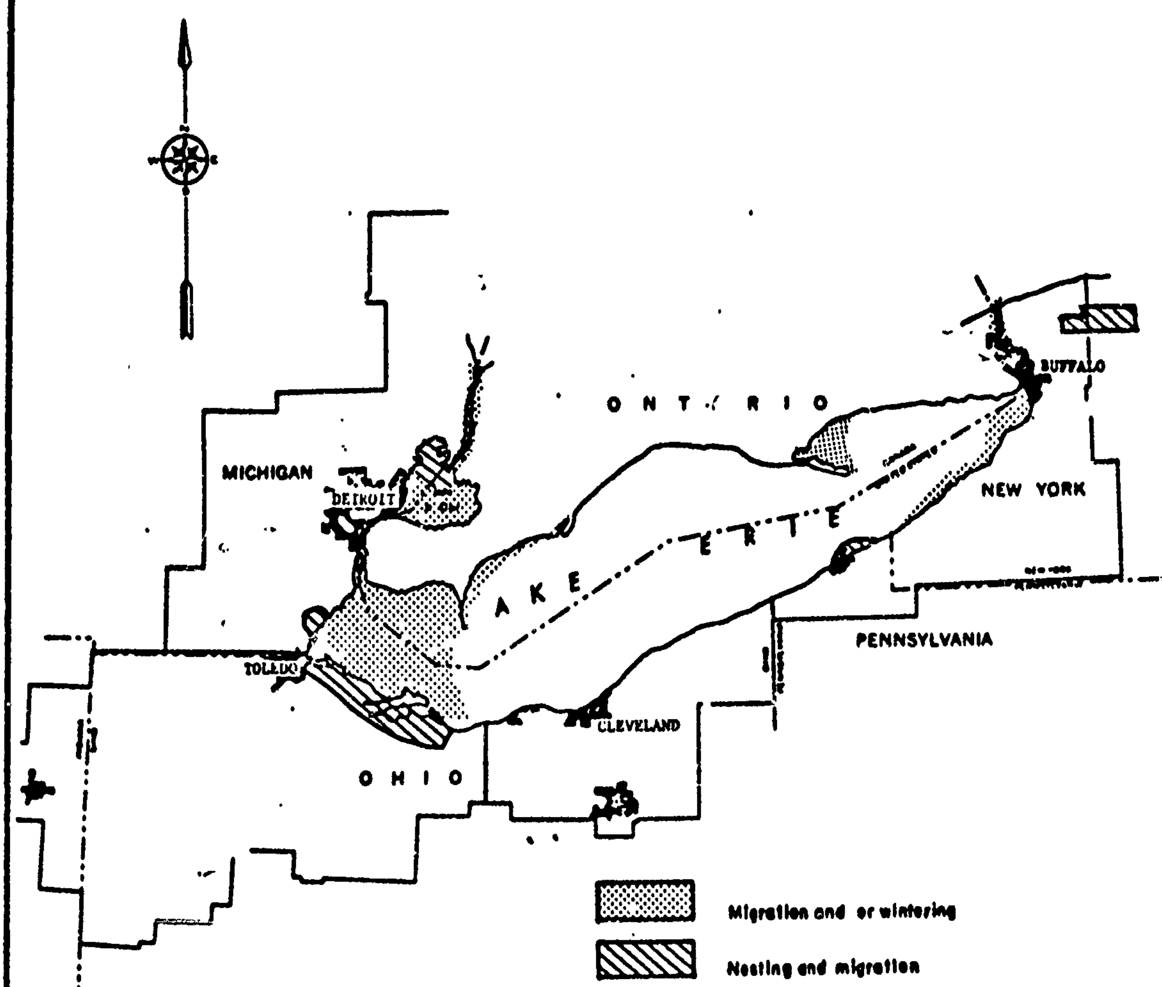
PRIMARY WATERFOWL USE AREAS OF LAKE MICHIGAN



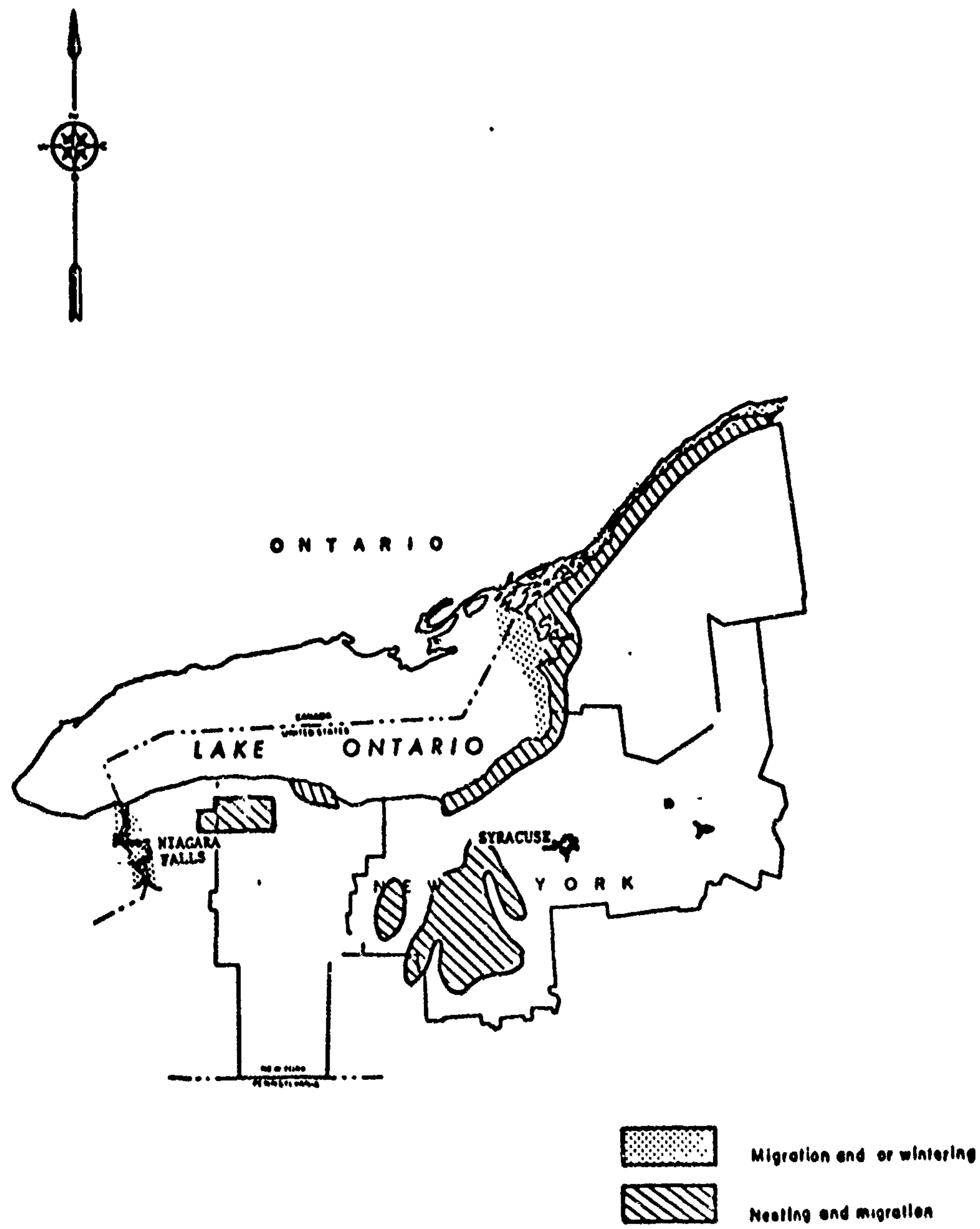
PRIMARY WATERFOWL USE AREAS OF LAKE SUPERIOR



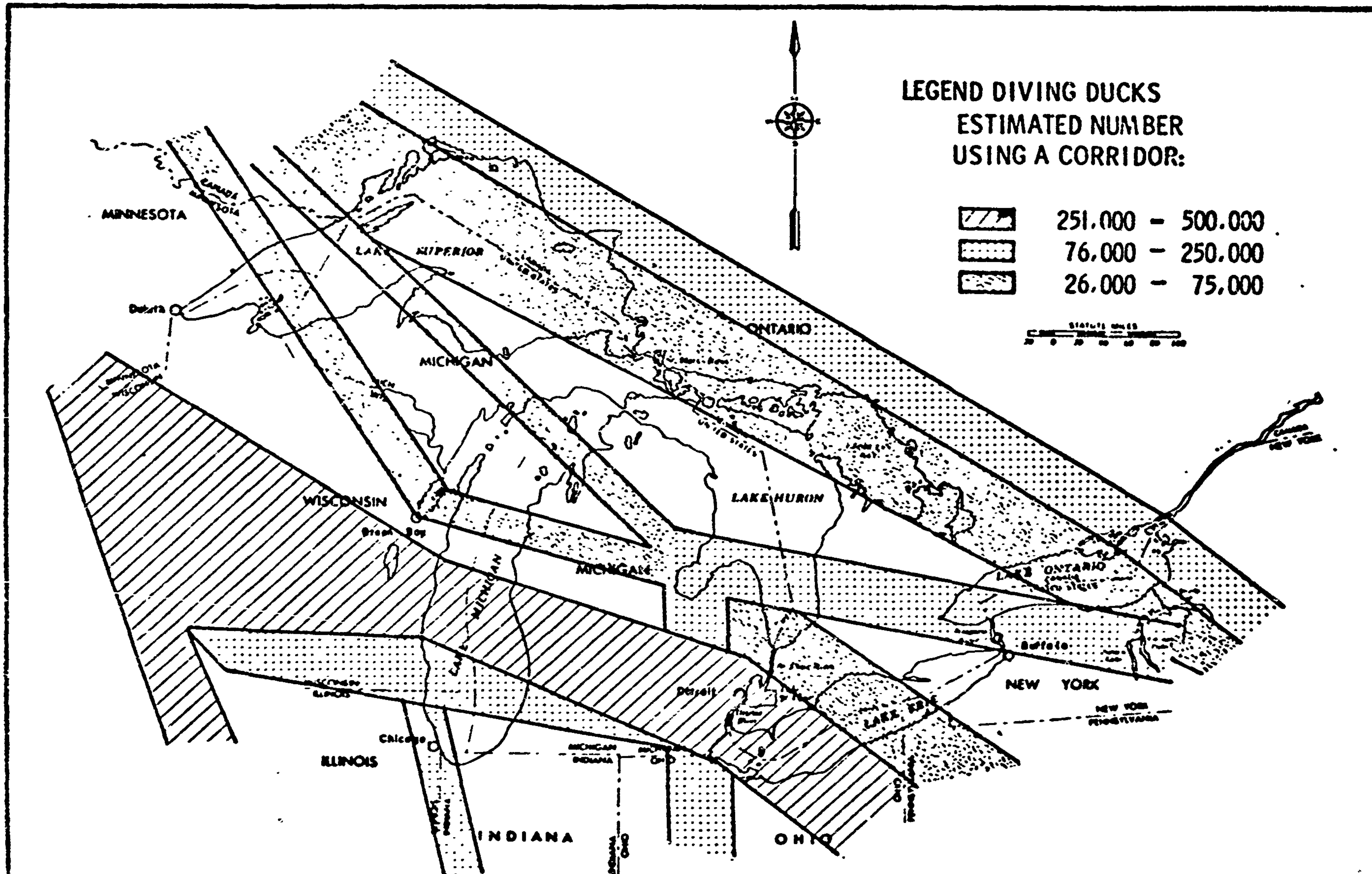
PRIMARY WATERFOWL USE AREAS OF LAKE HURON



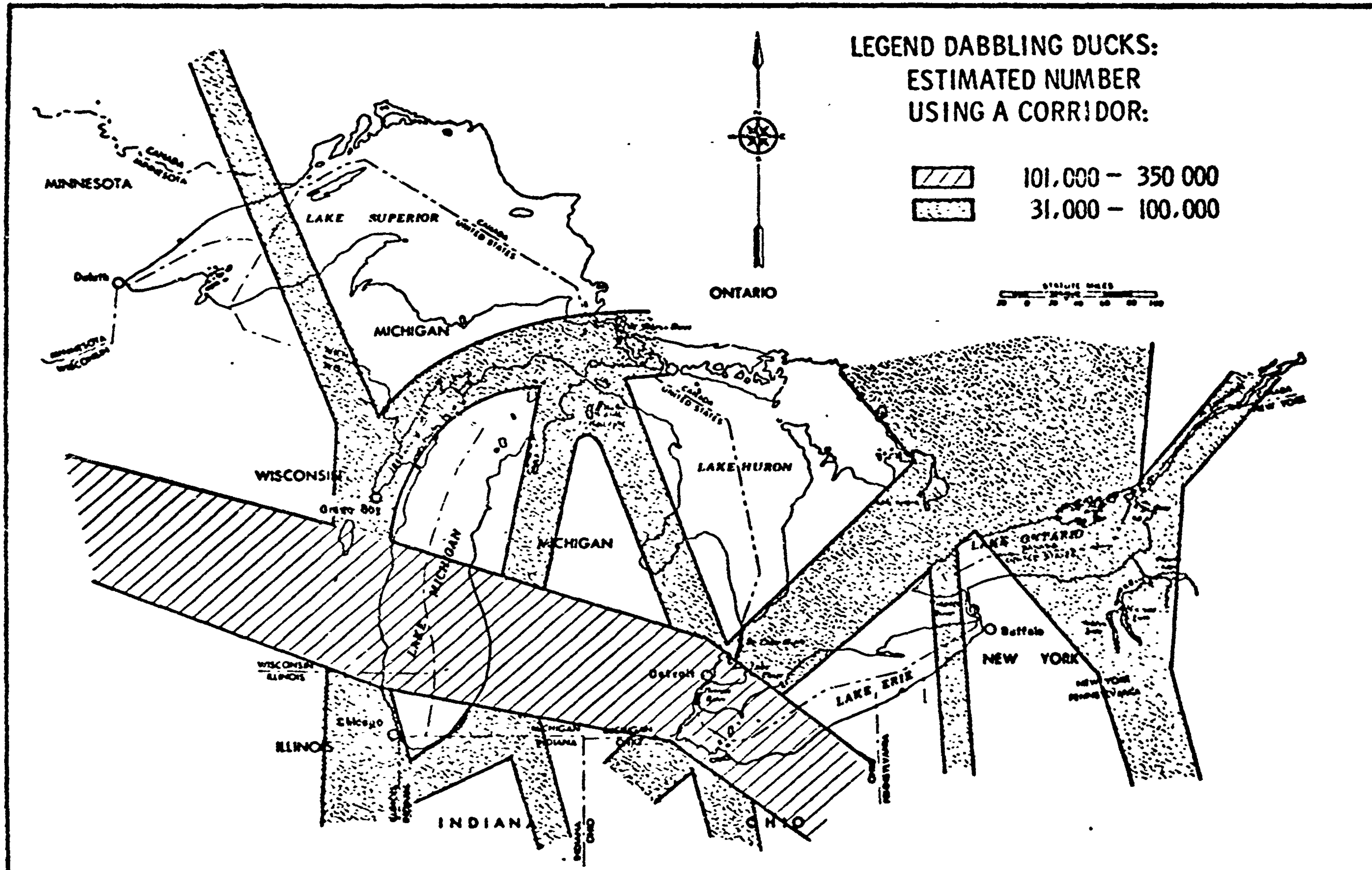
PRIMARY WATERFOWL USE AREAS OF LAKE ERIE



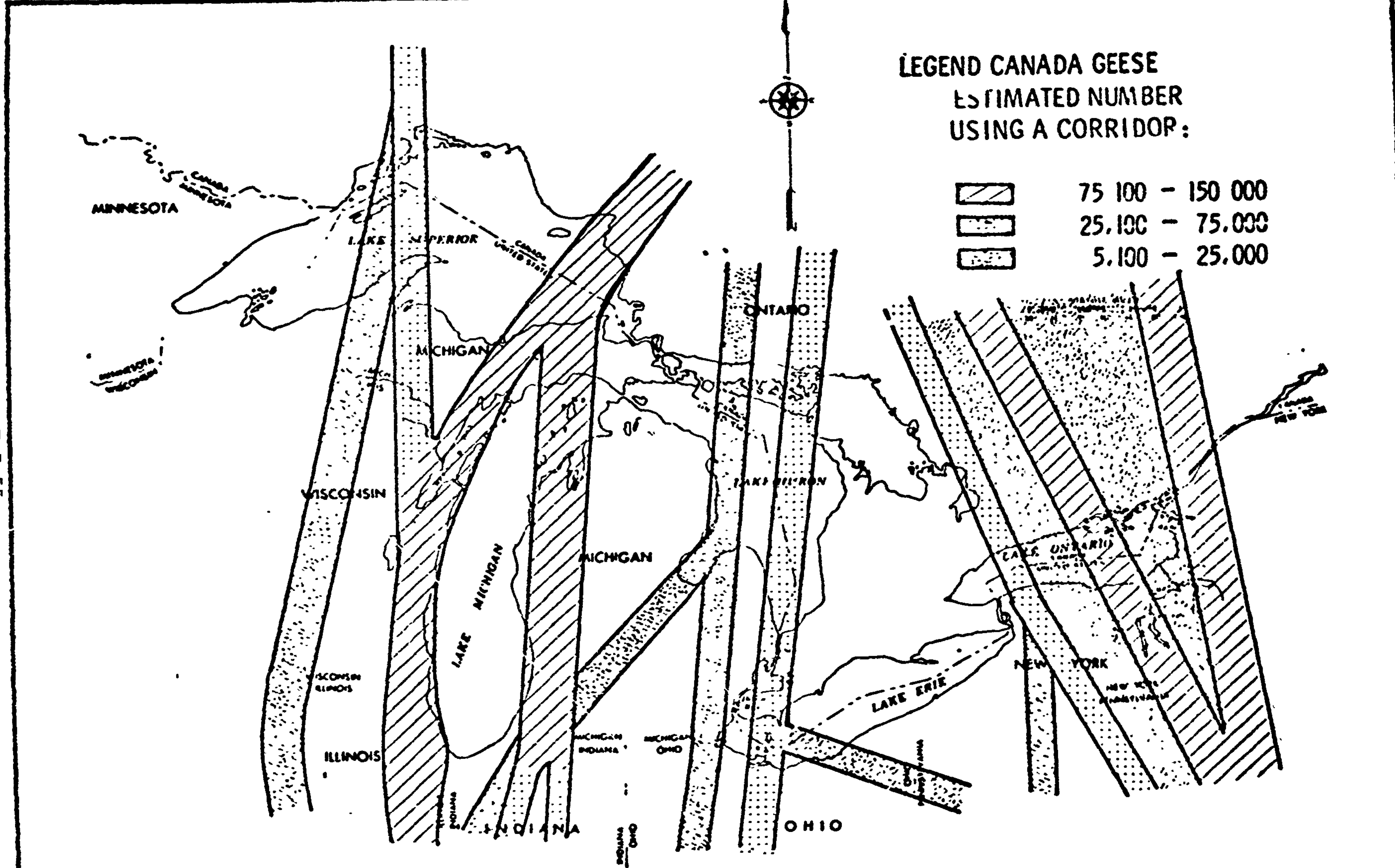
PRIMARY WATERFOWL USE AREAS OF LAKE ONTARIO



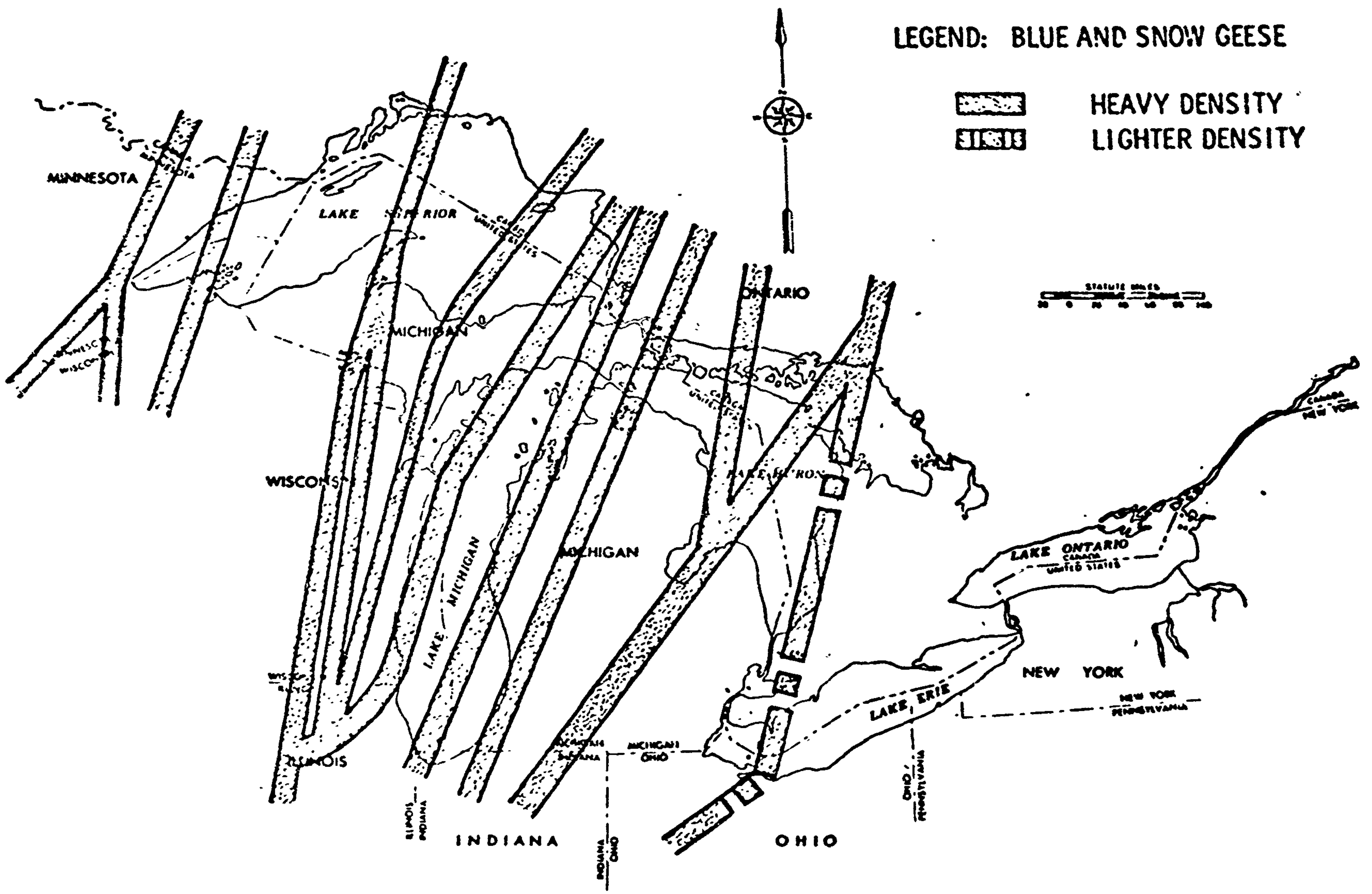
GREAT LAKES FALL MIGRATION CORRIDORS OF DIVING DUCKS



GREAT LAKES FALL MIGRATION CORRIDORS OF DABBLING DUCKS



GREAT LAKES FALL MIGRATION CORRIDORS OF CANADA GEESE



GREAT LAKES FALL MIGRATION CORRIDORS OF BLUE AND SNOW GEESE

less variable pattern. Optimum conditions for the muskrat usually occur at the water level that creates the largest inundated zone of cattail and associated plants throughout the fall and winter months.

Communities of benthic organisms include many different groups and an even wider variety of species. Most of these organisms inhabit the water and bottom depth zones between the water's edge and 20 feet. Only a few inhabit the deeper waters of the lakes. Deteriorating water quality has limited the range and numbers of snails, mussels and other benthic invertebrates which are important foods for aquatic birds and animals, especially in Lake Erie.

There are 664 miles of shore considered extremely valuable for fish and aquatic-oriented wildlife on the U.S. side. Canada Land Inventory maps show there are 301 miles of Canadian shoreline suitable for production of waterfowl and waterfowl hunting.

Biological Zones. Shorelands comprise some of the most unique ecosystems in the Great Lakes Basin. The shoal water and the shoreline, with its characteristic flora, supports a diversified and extremely significant fauna. Successful components of an individual shore-type environment are the dune grasses of the lake sands; the cedar, juniper, and hardwood of the Huron shore; the cattails and rushes of Green Bay, Saginaw Bay, and Lake Erie; and the stunted pines, hard woods, and rock outcrops of Lake Superior. Some 245,000 acres of bottom consisting of hard-packed sand, gravel, and ledge rock, subject to wave wash and scour, provide a minimum wildlife value. Shallow waters are classified as primary or secondary according to this value as habitat for aquatic plants and animals, based on its physical environment. The International Great Lakes Levels Board's report entitled "Regulation of Great Lakes Water Levels", 7 December 1973, cites that there are approximately 295,000 acres classified as primary shallow waters, and approximately 105,000 acres classifed as secondary shallow waters. (p. D-86).

A zone of emergent vegetation grows in the shallow water and on waterlogged soils along the shoreline. Plants whose leaves float on the water surface form another zone from intermediate depths. Submerged plants grow in the deeper waters, extending lakeward until limited by insufficient sunlight penetrating to the bottom.

On the Canadian side of the Great Lakes, there are 100,000 acres of wetland including shoal ares with emergent vegetation of high to moderate capability for sustaining wildlife. The extent of areas with low productivity was not determined.

Marshes are changeable natural ecological communities of plants and animals whose distribution is largely controlled by light, temperature, wave action, bottom soil and water depth. Marshes represent a transitional ecosystem between open water and dry land. Marshlands are extremely sensitive to large changes in water level.

The size of the marsh area is determined primarily by the slope of the lake bottom and shorelands. The more important marshes along the Great Lakes include rather extensive lake plains and river deltas which slope gently from the inland agricultural and undeveloped lands to the deeper waters of the lake.

The marshlands are one of the most productive ecosystems. Maximum production and growth of aquatic and semi-aquatic wildlife normally are benefited by a certain amount of water level fluctuation. Harris and

Marshall (1963)* have studied the effect of fluctuating waters on marsh vegetation and report that:

> "...It seems probable that some species of aquatic plants which are regarded as desirable in marshes have developed adaptations for survival in response to these natural fluctuations, even to the point where these plants may actually require such fluctuations for continued survival and seed production."

Human Environment and Resources

The physical environment of the Great Lakes Baisn has exerted a strong influence over the level and distribution of population and type and distribution of economic activities. The single most significant resource of the basin is the five Great Lakes and connecting channels. In addition to abundant natural resources and large agricultural potential, this source of water has allowed a highly industrial and agricultural area to develop. The United States portion of the basin contains one-seventh of the population on 4 percent of the total U.S. surface area and produces one-sixth of the national income. Within the Canadian portion of the basin, the importance is even greater. The Ontario portion alone contains almost one-third of the total population of Canada and produces nearly one-third of the national income. If the Canadian portion of the St. Lawrence River Basin is included, then the proportion of total population and economic activity rises to over 60 percent of the Canadian national total.

The Great Lakes system comprises navigation network between important industrial centers, agricultural production areas and the heavily populated eastern market.

*Harris, S. W.; and W. H. Marshall, 1963, Ecology of Water Level Manipulation on a Northern Marsh. Ecology 44:331-343.

Population. The Great Lakes Basin has contained 14 to 15 percent of the United States population during the period 1950 to 1975. The average population density is 113 persons per square mile, but it varies considerably from less than 20 persons per square mile in the Superior and Northern Huron basins to around 500 persons per square mile in the southern Michigan, Erie and Ontario basins.

Eight percent of the 29.3 million residents within the Basin are located within urban port areas along the shores of the lower Great Lakes. Major urban developments include Milwaukee, WI; Chicago, IL; Detroit, MI; Cleveland, OH; and Buffalo, NY.

Five of the Basin's 32 standard Metropolitan Statistical Areas (SMSA's) contain more than 1 million people. These areas are Chicago, 7.0 million; Detroit, 4.2 million; Cleveland, 2.1 million; Milwaukee, 1.4 million; and Buffalo, 1.4 million.

Future projections of the Basin share of the total U.S. population is anticipated to decrease from 14.1 percent in 1980 to 13.5 percent in 2020.

Employment. Employment trends for the eight states bordering the five Great Lakes have paralleled national employment shifts for most major employment sectors during the period 1940-1970. In 1970, nearly 4 million persons were employed in manufacturing, about 35 percent of the total persons employed. The major manufacturing industry group employers are primary metals, food and kindred products. Agriculture accounted for about 4.4 percent of the Nation's employment in 1970, and mining accounted for another 0.8 percent.

Future projection for the Basin's employment indicate that employmet will fall slightly from about 15 percent to a low of 13.8 percent in 2020.

Income. Historically, total personal income and per capita income within the eight states bordering the Great Lakes can be attributed to a heavy concentration of industrial activity. Basin personal income per capita has averaged from 10 to 20 percent above the national average during the period 1950 to 1970. Economic centers which lead the basin in per capita income are the metropolitan areas of Chicago (IL), Detroit (MI), Cleveland (OH) and Rochester (NY).

The rate of growth of total personal and per capita income in the Basin, following trends of population and employment, will decline relative to the nation in the 1970 through 2020 study period. The Basin's share of the nation's total personal income is projected to decline from 17 to 18 percent in 1940 through 1960 to less than 14 percent in 2020. The 1959 index of per capita personal income in the Basin, which was 113 percent in 1959, is expected to drop to 103 percent in 2020.

Production. The Great Lakes basin economy is basically industrial, utilizing the transportation and power advantages offered by the Great Lakes-St. Lawrence River system. In addition, there is significant agricultural, mining and forestry production. Commercial fishing, historically one of the oldest activities, has declined in commercial importance, although sport fishing has increased tremendously and is of great recreational importance to some regions.

Economic activity is greater and more intensive in the United States portion of the Basin, but the proportion of total Canadian activity in the Basin, compared with the national total, is much higher. The economic-industrial structures are generally similar in the two countries, with some important differences in the relative share of some industrial groups.

In the United States, more than one-fifth of the manufacturing employees, and capital expenditures are within the Great Lakes basin; in Canada, over one-half the national manufacturing employees, and capital

expenditures are within the Basin. The region is the primary focus of the iron and steel industry in North America, accounting for 40 percent of the U.S. production and 80 percent of the Canadian output. The Great Lakes ports serve an additional one-third of the U.S. Steel industry. The region also contains high proportions of other industries, including chemicals, paper, food products, machinery, transportation equipment and fabricated metal products. Mineral production is also important, particularly iron ore and limestone.

The western Great Lakes area produces about two-thirds of the nation's output of iron ore and one-twentieth of its domestic copper output.

Industrial water use in 1960 in the Great Lakes area was estimated to be 2.7 trillion gallons. Industries employed almost a half million persons.

Commercial fishing in the United States in 1964 totaled over 53 million pounds, half of which was taken from Lake Michigan.

Feed grains are grown in the Basin both for local use in the livestock industry and for export. The Basin is important for its dry bean production. "Hothouse" rhubarb, sugar beets, soft white wheat used in flour blending, and dairy farming are found throughout the regions. Cash crops, such as corn, soybeans, and vegetables, predominate in the more productive southern portion. Due to the favorable climate along the lakes, one of the nation's most important fruit and vegetable areas has developed. Forest resources continue to serve as a basis for economic development. Production of pulpwood, saw logs, veneer logs, and miscellaneous industrial timber products is substantial and is expected to increase.

Finally, the Basin has a major recreation and tourist industry. The extensive sand beaches and scenic shorelines of the Great Lakes, with water-related recreational opportunities, attract many users. Typical are

the cottage and summer resort areas of northern Michigan; northeastern Wisconsin; Georgian Bay, Ontario; and the Thousand Islands reach of the St. Lawrence River. Major tourist attractions include the Soo Locks, Niagara Falls and the Welland Canal.

The value of tourism in the U.S. portion of the Great Lakes basin has been estimated at $300 million annually. Canadian figures indicate that international tourism expenditures in the Great Lakes basin totalled over $500 million in 1971. The value of Canadian inland waters in all aspects of water-based recreation was about $1.5 billion in 1972 and is increasing annually at a 16 percent growth rate, with a major part ascribed to the Great Lakes and its tributary areas. Water-based recreation on the U.S. side is also growing rapidly.

Transportation. The region occupies a location strategic to the highly industrialized and well-populated north central United States and south central Canada, and is astride the transcontinental link between the major agricultural production regions of the west and midwest and the market areas of the east. The Great Lakes-St. Lawrence Seaway system provides a 27-foot deep navigation channels from Duluth-Superior to Montreal and 35-foot channels from Montreal to Quebec City. Over 100 billion ton-miles of waterborn freight are carried by this system each year.

The region could be considered tributary to Great Lakes harbors for shipment of overseas general cargo. In the United States, it includes the eight Great Lakes states and eleven additional contiguous states which generate about 25 percent of the U.S. general cargo export traffic. The tributary areas for overseas shipments of U.S. grain produce 79 percent of U.S. grain with the six midwest states bordering the Great Lakes producing 37 percent. The share of U.S. gain exports through Great Lakes harbors was 18 percent in 1971 and is projected to increase to 20 percent in 1980. Almost half of the Canadian wheat export shipments pass through Great Lakes-St. Lawrence Seaway ports and approximately one-third of all Canadian ship cargoes are handled in the system.

The railroads, motor carriers, airlines, barge companies and pipelines serving the region tributary to the Seaway system are extremely active competitors for much of the cargo tonnage which moves or could move through the Great Lakes-St. Lawrence Seaway system. However, such carriers assume a complementary service role for most of the domestic and oveseas traffic actually moving through the system. As partners in the total physical distribution process, they transport freight to and from Great Lakes ports and inland origins or destinations.

Recreation. The Great Lakes Basin has 17.8 million acres of public recreational areas. There is a great diversity of outstanding natural features such as forests, meadows, marshes, shorelines, islands, streams and lakes (both Great Lakes and inland). Many of these areas have exceptional scenic, wilderness, and aesthetic qualities which make them nationally significant. Recreational resources are not evenly distributed, being mostly located in the drainages of Lake Superior, Lake Ontario, and the northern parts of Lake Michigan.

In 1970, there were 14,516,000 acres of public recreational lands in the Great Lakes Region with over 544,000 acres of State, County and local parks. The 1970 estimate of 637.1 million recreational days is expected to increase to 861.3 million user days by 1980 and to 1,863.6 million days by the year 2020. The above figures do not include the man-days spent for fishing and wildlife resource base activities.

In 1970, the sport fishing effort was estimated at 81.2 million angler days, of which over 16 million were spent on the Great Lakes. By 1980, this activity is expected to increase to an estimated 106 million angler days, with Great Lakes demand projected at over 27 million. Residents of the Great Lakes Basin also purchased more than 2 million hunting licenses and spent over 24.8 million man-days hunting. This figure is expected to increase to over 32 million by 1980.*

*Great Lakes Basin Framework Study.

In general, the sport fisheries and wildlife resources provide a major attraction for tourists which provides for a multi-million dollar industry.

Recreational problems include land-use competition, high acquisition costs for lands, public opposition and legal restraints on recreational development, overuse of existing areas, inadequate planning, and environmental degradation. This last category is one of the greatest problem areas. Since 1961, a number of Great Lakes beaches have been closed due to polluted waters. Soil erosion and sedimentation, disposal of dredged materials, solid waste disposal, thermal waste disposal, farm fertilizers and pesticides, and air pollution are a few of the contamination sources adversely affecting the Great Lakes-St. Lawrence River Basin recreation resources.

Social characteristics include the interrelated aspects of population, employment, income and production discussed in the above paragraphs under "Human Resources." Significant characteristics with respect to the life style of residents in the study area are as follows:

(1) The utilization of ferry service for cross channel transportation along the St. Marys River and the St. Clair-Detroit River area. When this ferry service to the mainland is inoperable on the St. Marys River during the winter months, island residents rely on the river ice cover.

(2) Commercial navigation employees maintain a seasonal life style of spring, summer, and fall employment with the winter months open for possible vacationing and/or recreational activities.

(3) Ice-related recreation activities are common throughout the system; however, predominant locations have been identified. Major activity centers are Cape Vincent, Wellesley Island, Chippewa Bay and Coles Creek along the St. Lawrence River; and Waisky Bay, Mosquito Bay, Brush Point, Big Point, Sugar Island on Lake Nicolet, Neebish Island on West

Channel, Raber Bay, Lake Munscong and Mand Bay on the St. Marys River. Other recreational areas on the Great Lakes include Muskegon Lake, Pere Marquette Lake, Grand Traverse Bay, Saginaw Bay, Cleveland Lakefront and Maumee Bay State Parks, Sandusky Bay, as well as the island area in Lake Erie. Ice fishing, occasional ice boating, and snowmobiling are among the recreation activities which take place in the winter months on the Great Lakes waterways.

SECTION F-II

ENVIRONMENTAL IMPACTS OF THE PROPOSED PROGRAM

Activities related to an Extended Navigation Season Program began during the winter of 1971-72 under the Demonstration Program. The goal of the Demonstration Program was to determine the practicability of various methods, both structural and non-structural, to maintain extended season navigation on the Great Lakes-St. Lawrence Seaway System. Noted environmental impacts have been documented in several environmental statements of the Demonstration Program and in the 1976 Interim Feasibility Study.

The Interim Feasibility Study report states that the extended navigation season on the Great Lakes-St. Lawrence Seaway System is engineeringly and economically sound, with continuing environmental investigations recommended. The report recommends that a winter navigation program be adopted, comprised of proven existing structural and non-structural operational measures, to support a navigation season on the upper four Great Lakes and their connecting channels to 31 January (plus/minus 2 weeks).

The Interim Feasibility Report states that this extension to 31 January ($\pm$ 2 weeks) would have no irreversible, unacceptable adverse environmental impacts. This was based on assumptions and observations, made over the past several years of demonstration activities, while such navigation has been occurring. However, the report and the Winter Navigation Board considered it necessary to continue environmental studies to document the validity of assumptions, observations, and conclusions reached with regard to the expected impacts and environmental feasibility.

In January 1977, the U.S. Army Corps of Engineers requested the U.S. Fish and Wildlife Service (USFWS) to take the lead in formulating an Environmental Plan of Study (EPOS) for the entire Great Lakes System (Great Lakes-St. Lawrence Seaway).

The FWS assembled five Environmental Planning Task Force Teams to identify concerns and needed studies. Citizens and scientists provided extensive input. The FWS completed the initial plan, termed the Interim Environmental Plan of Study (EPOS), in March 1978. The Interim EPOS included more than 400 environmental concerns and studies suggested by scientists, Federal and state natural resource managers, private citizens and citizen organizations.

The three primary goals of the Interim EPOS were to determine:

1. What studies need to be undertaken?

2. Who should do them?

3. How much will they cost?

These quesitons were partially addressed in the Interim EPOS. The COE and FWS determined that the Interim EPOS should be refined and developed into an Environmental Plan of Action (EPOA). The purpose of the EPOA is to safeguard the environmental attributes of the Great Lakes System impacted by a Winter Navigation Project and is contained in Appendix D.

The Environmental Plan of Action is based on the principle that a Winter Navigation Project will be modified and, if necessary, a moratorium on Project activities would be put into effect if unacceptable environmental impacts are identified before operation and construction, or if encountered later. These unacceptable

environmental impacts could be identified during any of the post authorization phases including design studies, construction or operation. The intent is to identify all possible impacts during Phase I of the Design Studies.

The function of the EPOA is to provide a definitive plan which would derive the necessary environmental assessment data needed for a comprehensive evaluation of the extended navigation season program during post authorization and pre-construction studies.

The development of a definitive plan is necessary because the current state-of-the-art does not permit a comprehensive evaluation using the data currently available. This is largely due to deficiencies in technical information as related to existing environmental conditions, the degree and magnitude of foreseen or potential impacts, and the identification of impacts yet unknown[1]. It is also a generally accepted ecological principle that extrapolation of biotic information from one area to another is not a sound evaluation technique[2]. Therefore, the EPOA includes methods for assessing environmental impacts, and a list of studies to be conducted. The EPOA also includes an integrated environmental study and engineering schedule, the outline of a system for managing data includes a description of an overall system for selecting and scheduling studies so that the needed information would be available at a suitable time for environmental assessment and planning. The EPOA will be refined throughout a Winter Navigation Project as new information and insights are gained.

[1] Environmental Monitoring Plan, Great Lakes Basin Commission, 1979

[2] Comparative Study, St. Marys/St. Lawrence

This section of the Appendix examines the environmental impacts currently known, perceived, or considered potential and areas of environmental concerns for which sufficient information is currently unavailable. An EPOA program is proposed to gather the necessary information considered as essential for the environmental evaluation of the extended navigation season program.

Environmental concerns and impact analysis are addressed as to what effect the total proposed program could have on each environmental component category, rather than independently analyzing each program activity and its associated environmental impacts. Separate Environmental Impact Statement (EIS) or Environmental Assessment (EA) on activities proposed will be developed as appropriate. The approach being utilized would permit the reader to assess how and what level or degree individual activities could affect or impact on various environmental components; and to identify, and evaluate foreseen impacts or concerns within the respective environmental components.

For example, impacts and concerns expressed, relating to operation of a bubbler system could include: increased oxygen levels and resuspension of bottom sediments. This discussion is brought forth under Impacts on Water Quality. Concerns have been expressed on operation of the bubbler system in regard to fish movements. Also, if open water is created in the ice cover, its effects on water birds is a concern. These concerns would be addressed under Impact on Fisheries, and Impact on Wildlife, respectively.

Preceived/Potential Impacts on the Physical Environment

Impact on Air Quality

Air quality is a highly variable factor of the environment. Large changes occur within short distances due to population and

industrial centers and natural physical processes. Within the Great Lakes Basin, air quality varies from clean, in the more remote regions, to poor in areas of high industrial concentration, such as Duluth, Minnesota; Detroit, Michigan; Gary, Indiana; and Chicago, Illinois.

The Federal Clean Air Act, as amended in 1970 and 1977, sets forth National Ambient Air Quality Standards, defining maximum allowable ambient concentrations for six pollutants: suspended particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, photochemical oxidants, and hydrocarbons. These six pollutants have come to be known as criteria pollutants. There are two standard levels for each of these pollutants. The primary standard is designed to protect the public health. The secondary standard is designed to protect public health and welfare, which includes damage to buildings, plants and animals, and impairment of visibility. The ambient standards are listed below:

Ambient Air Quality Standards

Pollutant	Ambient Standards
Carbon monoxide (CO)	Primary and secondary standards are 10 milligrams per cubic meter (9 ppm) as a maximum eight-hour concentration not to be exceeded more than once a year, and 40 milligrams per cubic meter (35 ppm) as a maximum one-hour concentration not to be exceeded more than once a year.

Pollutant	Ambient Standards
Photochemical oxidants	Primary and secondary standards are 160 micrograms per cubic meter (0.8 ppm) as a maximum one-hour concentration not to be exceeded more than once a year.
Hydrocarbons (HC)	Primary and secondary standards are 160 micrograms per cubic meter (.06 ppm) as a maximum three-hour concentration (6 to 9 A.M.) not to be exceeded more than once a year.
Nitrogen oxides (NOx)	Primary and secondary standards are 100 micrograms per cubic meter (.05 ppm) on an annual arithmetic mean.
Sulfur oxides (SOx)	Primary standard is 80 micrograms per cubic meter (.03 ppm) on an annual arithmetic mean, and 360 micrograms per cubic meter (.14 ppm) as a maximum concentration not to be exceeded more than once a year. The secondary standard is 60 micrograms per cubic meter (.02 ppm) on an annual arithmetic mean, 260 micrograms per cubic meter (.1 ppm) maximum 24-hour concentration not to be exceeded more than once a year, and 1,300 micrograms per cubic meter (.5 ppm) as a maximum three-hour concentration not to be exceeded more than once a year.

Pollutant	Ambient Standards
Particulate matter	Primary standard is 75 micrograms per cubic meter (.028 ppm) on an annual geometric mean, and 260 micrograms per cubic meter (.14 ppm) as a maximum 24-hour concentration not to be exceeded more than once a year. The secondary standard is 60 micrograms per cubic meter (.02 ppm) on an annual geometric mean, and 150 micrograms per cubic meter (.058 ppm) as a maximum 24-hour concentration not to be exceeded more than once a year.

The U.S. Environmental Protection Agency has proposed an ambient air quality for lead. In addition, as directed by the 1977 Federal Clean Air Act amendments, the U.S. EPA is to consider establishing an additional standard for nitrogen dioxide.

Atmospheric conditions influence the overall impact that these contaminants, once having left their source, would have on air quality. Two important atmospheric processes are: diffusion of the individual particles due to "random" air motions about the plume centerline; and the mean transport of the entire plume mass by the prevailing winds. Over and around the Great Lakes both of these processes can be radically different from those experienced considerable distance inland, away from lake influences. During the winter months when the characteristic air mass temperature is much lower than the underlying water temperature, extreme thermal instabilities often result. Convective mixing cause rapid dilution of any effluent released into the atmosphere. With the exception of intense lake snow squall regimes and occasional land breeze circulation cells, mean wind directions are not radically altered as

air masses flow over the Great Lakes in winter (though wind speeds are frequently higher over water).

By contrast, during the summer (warm) season when advecting air masses are often as much as 30 degrees (C) warmer than the lake water surface temperatures, the frequent development of lake breezes (mesoscale circulation patterns) results in highly variable characteristics of diffusion and transport on spatial and temporal scales.[1]

Transportation and fuel combustion on the Great Lakes influences the regional air quality. Commercial vessel operation, which includes loading and unloading activities, is a source of air contamination. Fuel oil is the primary fuel used in Great Lakes commercial vessles powered by inboard engines, such as steamships, motor ships, and gas-turbine-powered ships.[2] Steamships are any ships that have steam turbines driven by an external combustion engine. Motor ships, on the other hand, have internal combustion engines operated on the diesel cycle. Gas turbines are not in wide-spread use and therefore, are not discussed, however, their use may become increasingly common.[3-4]

[1]Lyons, W.A. and C.S. Keen, Proceedings of the 2nd Federal Conference on the Great Lakes, ICMSE, pg. 222, 1975.

[2]Pearson, J.R., Ships as Sources of Emissions, (Presented at the Annual Meeting of the Pacific Northwest International Section of the Air Control Association, Portland, Oregon, November 1969.)

[3]Standard Distillate Fuel for Ship Propulsion. Reprot of a Committee to the Secretary of the Navy. U.S. Department of the Navy, Washington, D.C., October 1968.

[4]GTS Admiral William M. Callahan, Performance Results Diesel and Gas Turbine Progress. 35(9): 78 September 1969.

The air pollutant emissions resulting from vessel operations may be divided into two categories: emissions that occur as the ship is underway and emissions that occur when the ship is dockside or in-berth.

Underway emissions may vary considerably as fuel consumption fluctuates when vessels are maneuvering or docking. During such times vessels are operated under a wide range of power demands for a period of 15 minutes to 1 hour. Peak power demands may be as much as 15 times greater than during low demand times. However, once the vessel has reached and sustained a normal operation speed, the fuel consumed is reasonably constant.

At dockside, emissions continue as a ship generates power for light, heat, pumps, refrigeration, ventilation, etc; unless she receives auxiliary steam from the port; goes immediately into drydock; or is out of operation after arrival in port. A few steamships use auxiliary engines to supply power, but they generally operate one or two main boilers under reduced draft and lowered fuel rates, a much less efficient process. Motor ships generally use diesel-powered generators to furnish auxiliary power. The following table[5] shows the fuel consumption rates for steamships and motor ships while underway and in-berth.

TABLE II-1[5]

FUEL CONSUMPTION RATES FOR COMMERCIAL VESSELS

	Steamships		Motor ships	
Fuel Consumption (Oil)	Range	Average	Range	Average
Underway				
lb/hphr	0.51 to 0.65	0.57	0.28 to 0.44	0.34
kg/hphr	0.23 to 0.29	0.26	0.13 to 0.20	0.15

[5]Standard Distillate Fuel for Ship Propulsion, op. cit.

TABLE II-1 (CONT'D)

FUEL CONSUMPTION RATES FOR COMMERCIAL VESSELS

Fuel Consumption	Steamships Range	Steamships Average	Motor ships Range	Motor ships Average
gal/naut. mi	29 to 65	44	7 to 30	19
liters/km	59.5 to 133.0	90	14 to 62	38.8
In-berth				
gal/day	840 to 3,800	1,900	240 to 1,260	660
liters/day	3,182 to 14,400	7,200	910 to 4,800	2,500

Based on this data and the emission factors for residual fuel-oil combustion and diesel-oil combustion, emission factors have been determined for vessels and are presented in the next table.[6]

TABLE II-2[6]

EMISSION FACTORS FOR COMMERCIAL VESSELS

	Streamships				Motor Ships			
	Underway		In-berth		Underway		In-berth	
Pollutant	lb/mi	kg/km	lb/day	kg/day	lb/mi	kg/km	lb/day	kg/day
Particulate	0.4	0.098	15	6.8	2	0.49	16.5	7.5
Sulfur dioxide[a]	7S	1.71S	300S	136S	(SOx)1.5	0.37	43	19.5
Sulfur trioxide	0.1S	0.02S	4S	1.8S	-	-	-	-
Carbon Monoxide	0.002	0.005	0.08	0.036	1.2	0.29	46	20.8
Hydrocarbons	0.2	0.05	9	4.1	0.9	0.22	33	14.9
Nitrogen oxides (NO_2)	4.6	1.13	200	90.7	1.4	0.34	50	22.7
Aldehydes (HCHO)	0.04	0.01	2	0.9	0.07	0.017	2.6	1.2

[a] S=weight percent sulfur in fuel; assumed to be 0.5 percent for diesel.

[6] Ibid.

In addition to the emissions associated with those activities discussed above, a significant source of local air quality degradation occurs when a vessel purges its boilers of built-up carbon deposits, commonly referred to as "blowing its tubes". The resultant "cloud" of particulate matter could exceed Federal and local State air quality standards. Enforcement of this action is difficult. However, if a vessel employs this method of boiler cleaning on a regular basis, the resulting level of contamination could be less and the vessel operation could be at a more efficient fuel consumption level.

The implementation of the proposed Navigation Season Extension plan could alter the pattern of atmospheric loading on a local as well as a regional basis. As vessel traffic expands over a twelve month period and the work effort is increased in order to ply the waterways, as would be experienced by navigation through ice (including ice breaking operations), levels and distribution of emissions to the atmosphere could be affected. With an extended season for shipping, any air quality recovery that may have been associated with a non-shipping winter season could be altered, if not eliminated. Construction, dredging, and equipment operation as proposed for the project could also influence local air quality. However, due to the short term nature of these activities it is anticipated that these adverse air quality impacts would be temporary.

It is difficult to accurately assess the actual impacts that winter navigation could have on air quality. The factors to consider would include those associated with vessel operations, atmospheric conditions and the location of project activities. The impacts perceived at present would not significantly alter the air quality of the region.

Impact on Water Resources

The water resources of the Great Lakes System play an important role in the life style of the Great Lakes region. Not only does the 95,000 square miles of surface area provide a 2,342 mile waterway route, its waters provide a focal point for fish and wildlife, recreation, social life style and industry. Factors of water resources, such as water quality, levels and flows greatly affect the Great Lakes Basin.

The water resources of the Great Lakes System could, to varying degrees, be affected by activities proposed under the extended navigation season project. Such activities include: dredging, dredge material disposal in open water, winter navigation/icebreaking, construction of shore erosion and shore protection measures, the installation or modification of ice booms and aids to navigation and the construction and operation of water compensating works.

Levels and Flows. Proposed dredging activities on the St. Marys River consist of the removal of 3 million cubic yards of bottom sediments along 17 miles of the Middle Neebish Channel. Dredging activities in this river could alter local existing hydraulic conditions, such as current patterns, velocities, water levels and flow distributions. However, because of man-made and natural controls that regulate the flow through this waterway, it is not expected that the proposed dredging would affect the upstream water levels of Lake Superior, the downstream water level of Lake Huron, or the total flow in the St. Marys River.

Ice booms are proposed for installation at the head of the St. Clair and Detroit Rivers to reduce the possibility of ice jams and consequent flooding occurring in the lower portions of these rivers.

Stabilization of the ice fields and reducing ice jams could allow above normal winter flows in these rivers. To mitigate the effects that such an increase in winter flows might have on the water levels of the system, the construction of compensating works has been proposed in both of these rivers. These works would be operated to maintain the upstream and downstream levels and flows to those which would occur under natural conditions.

The proposed flapgates (see the Appendix B for Formulation of Detailed Plans) would be hinged so that they could be laid flat on the river bottom, removing the gates from the influence of the rivers, as well as alleviating their effect on the waterways or navigation during non-operation (summer) periods. Mathematical modelling has been employed to assist in the design of permanent structures (training walls) so that they would have little, if any, impact on summer levels and flows.

Dredging on the St. Lawrence River under any future option to maintain Low Water Datum consists of removal of 25.2 million cubic yards of material along approximately 10.2 miles of the International Section of the river. The purpose of this dredging would be to alleviate hanging ice dam problems in the river and allow the water level profile to return to normal conditions that would exist without these hanging dams. The velocities would be reduced in the area of the dredging and local current patterns could be altered. The water level of Lake Ontario would not be impacted due to regulation. This alternative method of maintaining Low Water Datum should not impact on overall power productivity, or the downstream portion (Canadian only) of the St. Lawrence River. For further information on the other alternatives and on water level and flow impacts refer to Appendix I (Levels and Flows).

Icebreaking and vessel operation activities in shallow parts (depths less than 50 feet) of the system, especially in the connecting channels, could cause currents created by propellers. The propeller wash could stir up bottom sediments in the shallow dredged channels. In addition, propeller wash and the vertical movement of water and ice away from the vessels could push ice under the adjacent ice cover on either side of the track. This ice could freeze and accumulate, forming a sort of ice rampart or ridge, changing the ice topography under the water. Depending on the reach of the waterway and the magnitude of ramparting, these ridges could alter existing water currents and affect circulation patterns. Without ice control in connecting channels, these effects could contribute to formation of ice jams and hanging dams, which could alter levels and flows of the channels. However, it has been shown on the St. Marys River that the proper implementation of ice control can result in little impact on total river flow or the water level profile. Further information on impacts on levels and flows is discussed in Appendix I (Levels and Flows).

Water Quality. Upon the initiation of dredging and disposal operations, temporary increases of localized turbidity would occur. This turbidity could restrict biological productivity in a number of ways; however, the two most significant effects with respect to water quality are the restriction of light availability to photosynthetic organisms and aquatic flora and the possible resuspension of organic/toxic laden sediments. With respect to light availability, large amounts of suspended material would tend to scatter (diffuse) light, resulting in decreased penetration from the water surface and a subsequent decrease in productivity of organisms dependent on this type of energy.

Oxygen Demand in sediment deposits is due largely to organic matter being utilized by micro and macro benthic organisms. In the undisturbed state, highly organic sediment is usually in an anaerobic

condition, with the exception of that portion of the sediment at the sediment-water interface, where reactions can be aerobic. Highly organic laden sediments could have a potential Oxygen Demand several orders of magnitude above the Dissolved Oxygen saturation level. The resuspension of partially decomposed organic matter and sludge would cause increases in the oxygen demand with resultant decreases in the dissolved oxygen content of the affected waters. This effect would be temporary and localized. Recovery time for a depressed Dissolved Oxygen concentration is a function of flow patterns and the physical characteristics of the sediment. Good mixing could provide a dilution factor. However, Isaac (1962) observed that resuspended sediment exerts more Oxygen Demand than in-situ material, and Martin and Bella (1971) noted that a mixing tends to increase the oxygen uptake. This effect would increase with an increase in vessel traffic.

Heavy metals are present in the environment naturally, although they have been added in large quantities by the activities of man. Ship operations and maintenance, municipal and industrial waste discharge and non-point sources; e.g., storm water and agricultural runoff, contribute considerably to the heavy metal content of sediments. Recent data indicate that the greatest heavy metal accumulation occurs in the top 20-40 cm of sediment and decreases with increasing depth. The implications of this fact are that the depth of dredging is of minor importance to the problem of heavy metal release/resuspension since the bulk of the accumulated heavy metals would most likely be removed with even the most shallow of dredging operations. Extensive research recently done by the Corps Waterways Experiment Station in Vicksburg, Mississippi, has shown that there is an insignificant amount of toxic metal released to the water due to the resuspension of sediments during dredging operations. It was found that toxic metal laden sediments resuspended in the water column would resettle with no more effect on the water environment than those associated with the resuspension and settling of uncontaminated sediments.

The effects of dredge material disposal in open water could be both permanent and transitory. Permanent effects include changes in morphology of the bottom surface and alterations in the nature of the material constituting the upper layer of the bottom surface. According to the composition of the dredged material disposed of, changes in the physical and chemical character of the water could develop, with possible associated permanent modification of the whole habitat of the water body. However, this must obviously be considered with respect to the size of the water body into which the dredged material is deposited. Beneficial effects noted include the development of new spawning reefs for fish.

Transitory effects could include turbidity at the time of disposal operations and related consequences, both favorable and unfavorable. Possible positive aspects of open water disposal in areas where eutrophication is not considered a problem include the production of soft bottoms by addition of material, the addition of nutrients, and the potential to produce increased biomass depending on site location and disposal material.[7]

Evaluation of a bubbler system for winter navigation was conducted for three years at Howard's Bay, Superior, Wisconsin. A major conclusion was that resuspension of significant amounts of potentially contaminated sediments appears unlikely when the effects of the bubbler are weighed against other factors operative in the harbor; e.g., backflushing from major storms on the lake, river water runoff, industrial and municipal contributions, and vessel traffic.

[7] International Association of Navigation Congress, Final Report of the International Commission for the Study of Environmental Effects of Dredging and Disposal of Dredge Materials, Annex to Bulletin No. 27 (Vol. II/1977).

Bubbler system operation alone does not cause significant impacts due to resuspension of bottom sediments, but bubbler system operations combined with winter vessel operation could magnify the potential effects of vessel movement in shallow harbors or channels by increasing the duration and distribution of resuspended sediments.

It has yet to be determined whether icebreaking and vessel passage cause significant deterioration of water quality within the system. Over large areas of the Great Lakes, such deterioration appears unlikely. Potentially affected sites would be the shallow, contaminated regions within the system; i.e., western Lake Erie, Saginaw Bay, harbors, and connecting channels. Propeller wash, illegal vessel operational practices (bilge pumping in open water), ice jamming with resultant increases in turbidity and sedimentation, and the potential for oil and hazardous material spills could create severe water quality problems related to winter navigation. It is the recommendation of the EPOA that a study should be designed to show the effects of winter navigation on the water quality of the whole system as well as that of each lake system. This study would go beyond site-specific water quality studies to determine whether winter navigation has a system-wide effect on water quality and the effects of increased shipping transits. Based on the findings of these studies and known areas of major concern, the appropriate actions, regulations, and enforcement could be carried out to mitigate, if not eliminate, such potential problems.

In summary, before a more detailed environmental evaluation can be made on the specific effects of the proposed program, additional information is considered necessary. Areas of studies that are proposed include: (a) site-specific water resource base condition studies, where data gaps exist; (b) studies on the combined effects of vessel movement and bubbler system operations; and (c) monitoring and validation of perceived impacts related to vessel operations in an ice environment, including icebreaking activities.

Further information on water resources studies being proposed or currently conducted is contained in Appendix I, Levels and Flows, and Appendix E, the EPOA.

Impact on Sediment Transport and Shore Erosion

In order to analyze the role of ice and winter navigation in sediment transport and shoreline erosion, the Cold Regions Research and Engineering Laboratory (CRREL), of the Corps of Engineers identified erosion prone areas within the Great Lakes, their connecting channels, and the St. Lawrence River that could be created or accelerated by winter navigation. Areas of concern included the direct movement of ice in contact with vessels, propeller wash, drawdown and surge, dredging, and ice control structures (ice booms, etc.). The significance of these various factors depends on a number of local conditions, such as the bathymetry, water levels, soil conditions, ice conditions, and the presence of other transport agents (e.g., natural currents or waves).

The role of ice and cold temperatures in sediment transport and shoreline change has many facets. Ice formed on a shore or river bank may isolate and thereby protect the soil. Ice formation can, however, cause significant localized shoreline damage by gouging ordinarily stable beach or bank formations, removing protective vegetation, by a freezing sediment at the ice-soil interface and by entrainment of sediment within the ice structure. During spring breakup this nearshore ice may migrate considerable distances before melting and releasing the entrapped sediment. Even low rates at which material is removed from a river bank or steep coastal bluff can be significant since this material is not easily replaced in nature.

Ice could exert a significant effect on the general hydraulics of the system being studied. In a coastal zone, ice tends to dampen the effects of winds, waves, and currents during severe winter storms. The development and presence of an ice foot, however, has been observed to exert an as yet undefined influence on nearshore bathymetry. This nearshore bathymetry is important in the dissipation of wave energy during ice-free periods.

In a river system the presence of an ice cover changes the open channel conditions into a form of closed conduit flow with resultant changes in velocity profiles and distribution. The presence of ice jams, frazil dams or other ice irregularities causing a channel constriction could alter current patterns, velocities and water levels and flows. These same features may also deflect the flow of the river against an erodible bank or bed area. Winter navigation, by disrupting the natural ice cover characteristics, could aggravate any natural impacts of the ice. Similarly, an ice cover could alter and even amplify the effects of navigation on system hydraulics and sediment transport.

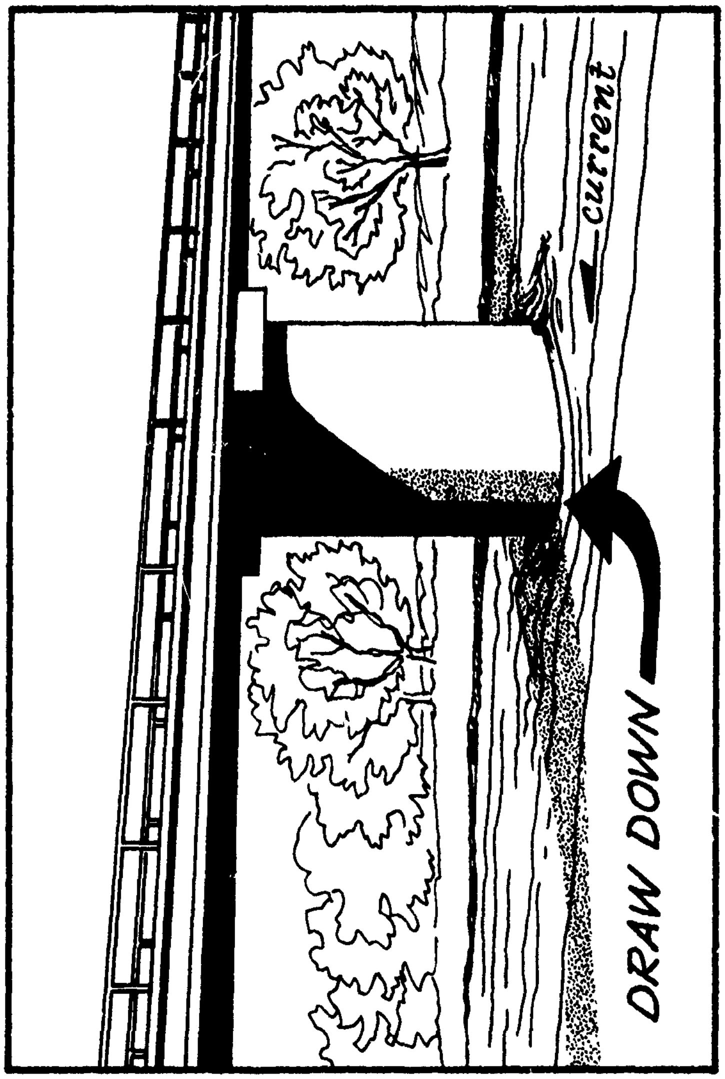
Shore damage due to the lateral movement of ice induced by vessel passage is ordinarily small, limited to early or unstable ice conditions, and shore areas in close proximity to the navigation track. The resultant damage, while possibly significant, is unpredictable, infrequent, and difficult to quantify.

A reach of shoreline could be affected over a period of years, but only a small portion of such a reach may be affected in any one year. Mitigative measures, such as vessel speed restrictions and/or shore protection, are being considered, a discussion of which can be found in the Main Report.

To aid in addressing the issue of ship induced forces in a channel environment, the following summary explanation of the effects of these forces is provided, with special emphasis on winter conditions.

Wave action is the mode of action normally associated with ship-induced shoreline erosion. When water is deep compared to ship dimensions, a system of diverging and transverse waves develops. Diverging waves are those which form the familiar "V" shaped wave pattern associated with ship passage, while transverse waves form a less noticeable wave train which follows a vessel and is oriented normal to the sailing line. Under such conditions the low waves produced by commercial vessels navigation are generally much smaller and less damaging than those produced by recreational craft, particularly when vessel speed and distance to shore are considered. In addition, winter ice conditions tend to dampen out these waves.

During normal flow conditions, any constriction in a channel would cause the water surface to drop in the vicinity of the constriction. An example of this is flow through bridge piers. (Please refer to Figure II-1). When a vessel (a constriction) is in motion, even in deep water, the water level in the vicinity of the ship is lowered, and the ship with it. For the same ship this effect is increased with an increase in vessel speed or a decrease in water depth. When a ship enters restricted water areas, there is considerable change in flow patterns about the hull. The water passing beneath the hull must pass at a faster rate than in deep water, and as a result there is a pressure drop which increases vessel squat. In a channel which is restricted laterally this effect is further exaggerated. An interaction may also take place with a lateral channel restriction which tends to push the bow away from a boundary and draw the stern toward it. These effects can occur independently when a channel is restricted either laterally or vertically and unrestricted in the other direction.



DRAWDOWN AROUND BRIDGE PIERS

FIGURE II-1

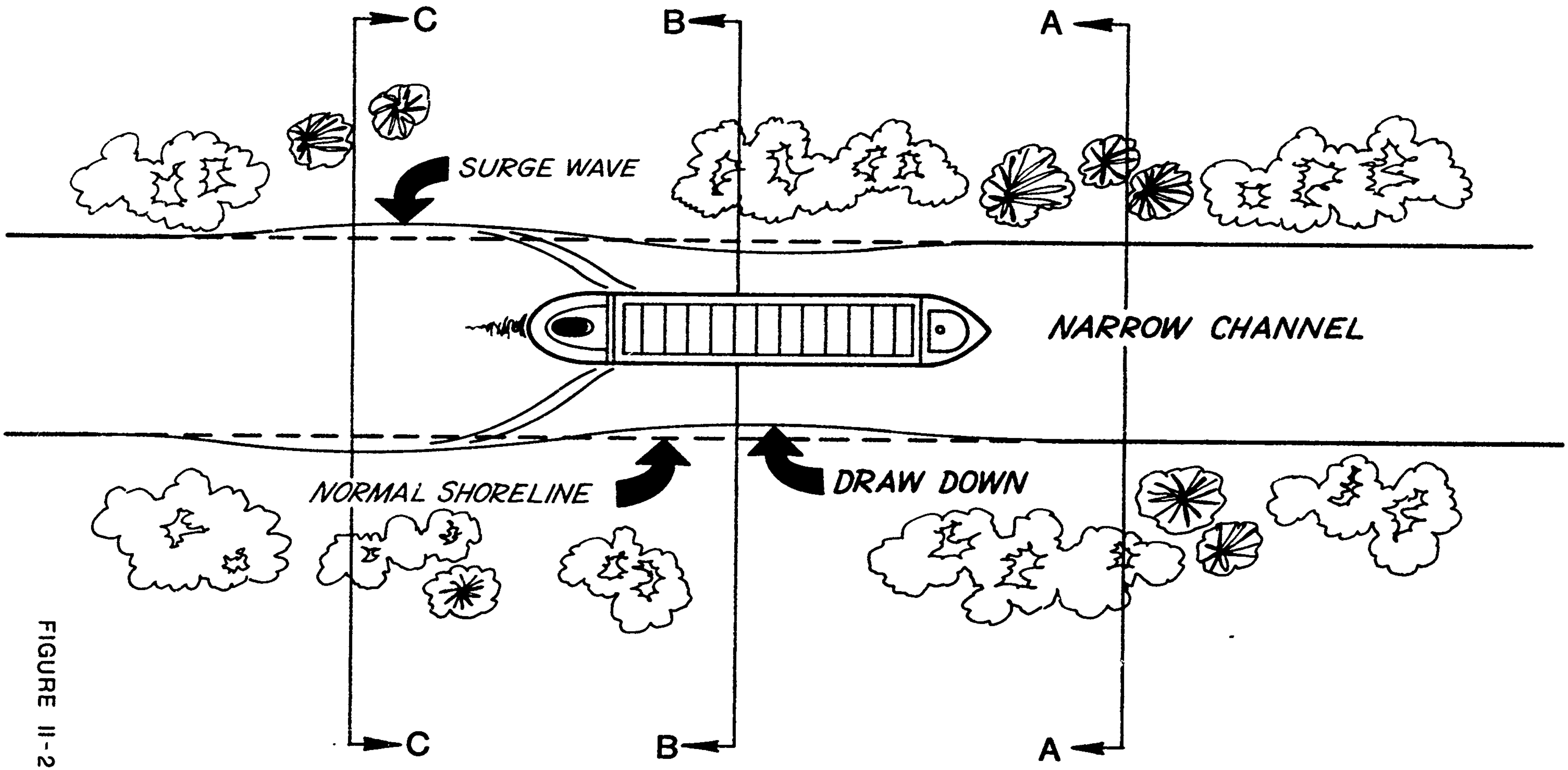
The water level drop in the vicinity of the ship is in effect a trough which extends from the ship to the shore and which moves along the river or channel as the ship moves, and at the same velocity as the ship. Further, as the ship's speed increases, the moving trough deepens (Figure II-2).

The phenomenon of nearshore "drawdown and surge" during vessel passage may be explained in terms of the moving trough. In sufficiently deep water, the moving trough appears as a fluctuation in the elevation of the water surface. To an observer in a shallow or nearshore area where the depressed water recedes from the shoreline as the ship passes, is followed by an uprush, and finally a return to normal level after the vessel-induced surface waves are dampened (Figure II-3).

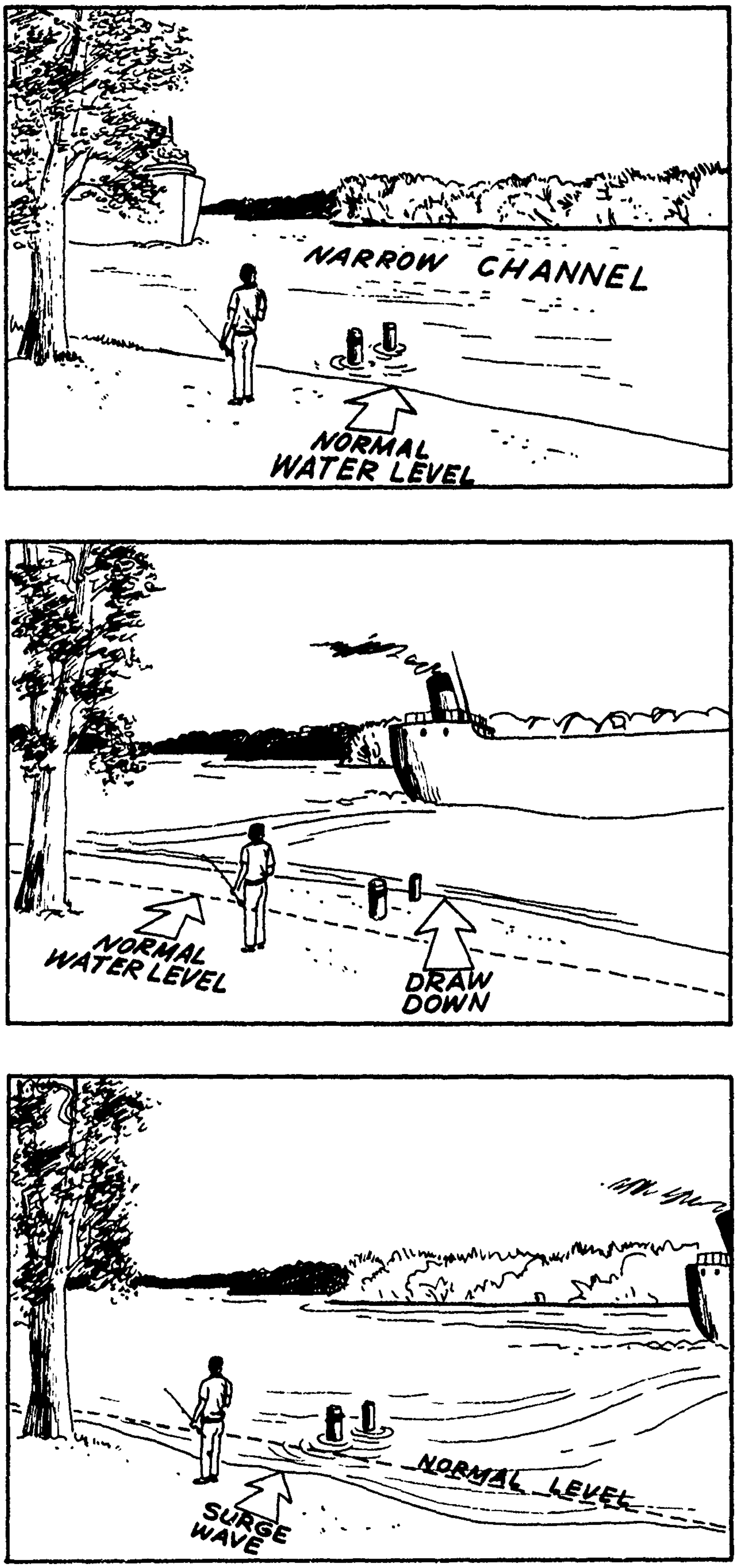
The local shore bathymetry will have a pronounced effect on the degree of drawdown and surge experienced at a point along a channel shore. Shallow water near the shore will tend to amplify the drawdown and surge effect at that point. A gently sloping shore can cause the largest surges, as the shallow water will retard the progress of the surge wave, and the water will tend to "pile-up." This would increase the effects that these changing water levels would have on shore erosion and sediment transport.

Significant drawdown and surge could occur in a channel even if it is ice covered. The movement of water away from the shore and its return will occur under the ice (Figure II-4). This movement of water could crack and move the ice. These cracks are known as active or tension cracks and are often parallel to shore, and can mark the division between grounded shore ice and floating ice. The translatory movement of water has been observed to cause the ice to break at or near the shore, allowing sediment-laden water to spray out onto the ice cover. Unfortunately, with this sediment-laden

FIGURE II-2

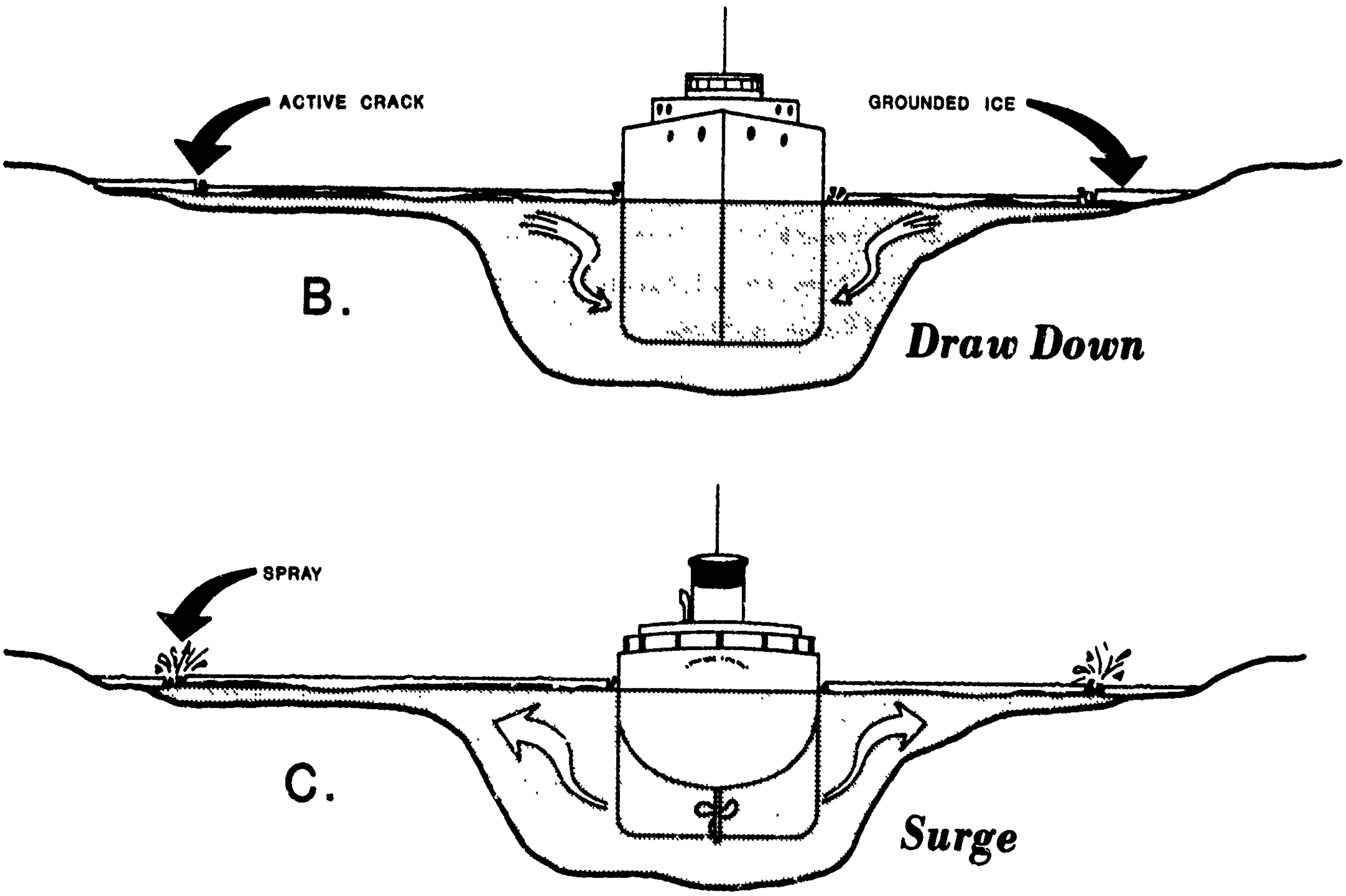


DRAWDOWN AND SURGE
(SECTION LINES REFER TO FIGURE II-4)



SEQUENCE SHOWING DRAWDOWN AND SURGE
AS IT MIGHT APPEAR TO AN OBSERVER

FIGURE II-3



DRAWDOWN AND SURGE UNDER AN ICE COVER

FIGURE II-4

water, benthic organisms, aquatic vegetation and fish have been observed, on occasion, sprayed out onto the ice cover on the St. Marys River. If an active crack (one which remains broken throughout the season) is present, a nearshore trough could be formed in soft bottom sediments. With appropriate speed controls, such impacts could be minimized. Also, with time the situation should stabilize.

In order for sediment transport to occur, near bottom water velocities sufficient to overcome a sediment particle's resistance to motion must exist. These water velocities may be due to ambient river conditions, wind driven waves, general turbulence, or ship-induced effects among others, and might be enhanced by channel configuration or ice irregularities. During vessel passage, large and rapid changes in river velocity magnitude and direction can occur. Measurements of near bottom water velocities during vessel passage have shown currents to undergo a 360 degree rotation in direction, with velocities in all directions significantly greater than the ambient downstream current.

Although ship waves and hydrodynamic effects of vessel passage as they relate to maneuverability and power requirements have been studied in the past, the influence of vessel passage on natural flow patterns and distribution as it relates to adverse environmental impacts is not yet understood.

A field investigation was conducted on the St. Marys River near Sault Ste. Marie, Michigan, to determine physical changes occurring due to vessel passages with a river ice cover. Measurements included ice thickness, river velocity alterations, vessel induced river drawdowns, and sediment translocation. Results indicate that critical combinations of river velocity alteration and pore pressure response in bottom soils due to river drawdown would cause bottom sediments to be shifted.

It has been established that sediment transport does occur under some combination of conditions. However, the river velocity-pore pressure response relationship necessary to initiate sediment suspension and translocation is unknown. A combined theoritical and laboratory study would be necessary to gain the ability to predict sediment movement. Only then will a rational method be available to provide vessel speed regulation or even curtailing of vessel movement in certain areas during periods of particular biological activity.

Three modes of transport of granular bottom sediments have been observed during both ice-covered and ice-free conditions. They are bed load, which is typified by a pattern of slowly migrating sand ripples on the river bed; saltation load, the movement of individual sand grains in a series of small arcs beginning and ending at the river bed; and a process which will simply be called "liquefaction."

On several occasions, liquefaction has occurred with the passage of large, deeply loaded vessels at speeds higher than normal.[8] Liquefaction of the bed has been observed by divers working on the surf zones of lakes and oceans and often may also be ovserved from shore as waves break near shore. In the presence of a reasonably horizontal velocity field, the action seems to occur in two steps. Initially the bed seems to expand upward somewhat. This is immediately followed by a dispersion into suspension of the uppermost part of the sediment bed and a movement of the temporarily suspended mass in the water current. In the absence of a current, the bed simply quakes or expands and individual particles move upward. Bed equilibrium is rapidly re-established by gravity forces.

[8]Wuebben, J.L., G.R. Alger and R.J. Hodek (1978) Ice and Navigation Related Sedimentation. Proceedings of the Fourth International Symposium on Ice Problems, IAHR, Lulea, Sweden, August 7-9.

Since the drawdown and surge mechanism usually sets up water velocities in opposite directions, there can be a tendency for their effects to cancel. However, natural currents or a sloped bottom could act in conjunction with vessel effects resulting in a net transport downstream or offshore towards the navigation channel.

Another way in which the net sediment transport may increase is if material is carried out of bays and around islands. In a small bay, sediment in shallow water may be moved around a point of land or into deeper water where the vessel effect is not as pronounced, allowing the sediment to settle.

Around islands, or points of land, vessel effects could cause sediment to be transported around the point. Since the land then shields the sediment from vessel effects, there is no mechanism for the sediment to be returned.

During winter ice condiditions, the passage of the moving trough (drawdown) can cause the grounding of an ice cover in shallow water and nearshore areas, resulting in the ice sheet cracking near shore. With recurring moderate water level fluctuations, these cracks do not substantially refreeze and can provide an ice movement relief mechanism. Continuing vertical and horizontal movement of the ice cover may cause the accumulation of ice debris at these active cracks resembling pressure ridges. Depending on the characteristics of crack formation, ice dams may develop at the cracks which extend to the river bed. This reduction in river area and the potential effect that a passaging vessel may have on water velocity, sediment could be distributed further downstream. The mechanisms described above could have effects beyond shoreline erosion. Large areas of grounded ice resulting from the packing of brash ice under the ice cover or increased frazil production due to increased open water areas have also been proposed as a possible medium for the transmission of

ship-induced vibrations to the shore and shore processes.[9] These vibrations have been reported to range from aesthetically disturbing to structurally damaging in certain limited areas.

Local residents in certain constricted portions of the St. Marys River have complained of disturbing vibrations in their homes with the passage of ships during winter navigation. Based on interviews with local residents, it appears that these vibrations may well be severe. The distrubance is limited to an area between Frechette Point and Six-Mile Point of the river. Since the problem of ship-induced vibrations has only recently come under consideration, the cause, mechanism of transmission and severity of these vibrations have not yet been determined. An investigation is underway by the Corps to determine the cause and mechanism of transmission of the vibrations and the relative significance of the vibrations.

Disruption of an ice cover may also have some as yet undefined effect on ice movement and damage by natural forces. In the case of relatively ice-free rivers such as the upper Detroit-St. Clair Rivers, the disruption of an ice cover on the lakes upstream may allow large quantities of ice to pass through. This has been observed to cause bottom scour and ice piling at bends and the upstream ends of islands. This is a natural phenomen on which could be aggravated by winter navigation. The proposed ice control structures should eliminate or reduce these effects.

In most coastal areas, natural shoreline modification forces such as waves and currents would be far more significant than any vessel related effects, and in most cases, the shipping lanes do not come

[9]Wuebben, J.L. (1977) <u>Ship-Induced Vibration Program, St. Marys River, Michigan</u>. USACRREL Technical Note.

near enough to the shore for vessels to have a noticeable effect. In some more protected areas that may not be true. Ice movement problems after disruption could be particularly important in coastal areas with significant wind driven ice push.

Propeller wash, while sometimes a significant effect, is generally unaffected by the presence of ice. This is a fairly localized disturbance, affecting the area immediately adjacent to the vessel. Propeller wash or bottom disturbance could be intensified during times when a vessel "squats" in shallow waterways while pushing an ice field. This squatting effect brings the vessel's propeller into closer contact with the channel bottom, and increased thrust is applied at the same time to overcome the resistance of the ice.

Studies being recommended for evaluation of the effects of winter navigation on shore erosion and sediment transport are presented in Appendix E.

Potential Impact on the Biological Environment

Implementation of a proposed Navigation Season Extension Project would cause environmental impacts on biological communities within the Great Lakes basin. The impact could be incurred through icebreaking, vessel movement, construction activity, dredging, bubbler system operation, and water and ice control structures. Open deep water areas of the Great Lakes are not foreseen as being significantly affected. The greatest concentration of impacts would occur in the nearshore zones and connecting channels in the vicinity of program activities. Within these two areas fish, wildlife, and their habitats could be affected. These shoreline habitats deemed sensitive to the proposed program activities include littoral zones, coastal wetlands, and shoal areas of the connecting channels and harbors and fish refuges. Therefore, impact discussion will mainly discuss the sensitive areas.

Impact on Benthic Communities

Activities which could affect benthic communities (communities of organisms attached or resting on the bottom or living in bottom sediments of a river or lake) are: dredging, vessel operations, including icebreaking, bubblers, construction of shore protection measures and the installation of ice booms and navigation aids.

The most pronounced effect that the above stated activities have individually or in combination with other activities is the removal/disruption and suspension of bottom sediments, including benthic (bottom dwelling) organisms. Impacts have occurred in critical reaches of connecting channels, harbors and in shallow offshore areas.

Relatively, impacts induced by dredging, commercial vessel operations and icebreaking are more significant than the impacts from bubbler system operation, shoreline protection measures, and the installation of ice booms or aids to navigation.

Dredging operations would physically alter the sediment-water interface in the areas of dredging. This effect could impact on benthic communities by either destroying, removing or displacing benthic organisms. It should be noted, however, that dredging has been, is being, and probably will be accomplished as both an economic necessity and a recreational need.

On the other hand, it has been theorized by the U.S. Fish and Wildlife Service that dredged commercial navigation channels could serve as dispersal routes or places of refuge for mobile benthic organisms during periods of extreme cold weather. Passage of vessels during such times could dislocate these organisms, resulting in a high rate of mortality and causing a significant drop in aquatic food

production for fish. Impacts of such an occurrence would not be immediately noticeable but could show up in reduced production several years in the future or in reduced species diversity.

Impacts caused by icebreaking and vessel operations on the benthic community are due to physical alteration; i.e., abrasion and scour, of the sediment. This physical alteration can be caused by vessels, winds, and waves pushing the ice into shallow areas where it contacts the bottom and abrasion takes place. This action could be continuous, thus creating an unstable environment that prevents benthic organisms from colonizing the habitat for the winter season. Recolonization could occur after ice breakup. These impacts may or may not be major. Many studies in the EPOA would look into this situation.

Vessel operation in an ice environment increases the ship energy requirements. Because of the increased energy requirements for forcing a ship through ice, scouring of the channel bottom by propeller wash could occur. This could result in suspension of bottom sediments and benthic organisms into the water column. Vessel operation in ice environments could also impact on benthic communities through creation of a drawdown and surge of waves in confined areas (as explained in the section on Impacts on Sediment Transport and Shore Erosion).

A study was conducted to determine if the loss and environmental disruption, due to vessel induced pressure waves, were significant to the total estimated benthic population at selected sites in the St. Marys River. The study showed that for one meter length of crack, approximately 10 organisms were displaced per vessel passage, or 0.1 percent of the existing benthic population below the sample sites. These findings proved to be insignificant due to the fact that observations during the past winters would indicate that the winter

of 1978-79 was not characteristic as it related to the frequency of relief cracks and the subsequent ice surface contamination by sediments and benthos (evaluation of benthic dislocation due to pressure waves initiated by vessel passage in the St. Marys River).

The minimal effect experienced during 1978-79 was attributed to the decrease in shipping activity (number of vessels per week), the mode of icebreaking (Katamai Bay vs. the Mackinaw) and the rate and type of ice formation due to the winter. If the frequency of activity by upbound and downbound vessels had been maintained at 4+ passages per week and if the Mackinaw had been used for icebreaking, it is anticipated that the previously observed shore ice - sheet ice junctures would have maintained the open fractures through which the benthic dislocation effect had been observed in the past. The degree in frequency coupled with the extremely cold periods of extended freezing allowed interstitial ice to become strong enough that only when vessels reached critical speeds did new fractures form. Early winter fractures occurred very close to shore and produced only water and some fine sands. These reaches of the littoral zone are traditionally low or devoid of benthic representatives. It is not until the shore ice has moved out to a depth of 1 to 1.5 meters that aquatic invertebrates and vertebrates appear on the ice surface. This investigation indicated that ice surface loss of organisms under present conditions of operation (1978-79) does not merit further study and that the losses to the system are insignificant in comparison to the annual mortality associated with the area studied. This recommendation did not exclude the possibility that subsurface dislocation and disruption of the benthic ecology does exist.

Proposed project activities which create open water or provide for areas of thinner ice cover could influence the periphytic communities (community of organisms, both plant and animal, attached

or clinging to surfaces projecting above the bottom). This influence, e.g., light penetration and possible local water temperature changes, are considered as not having a significant adverse impact on the community due to proposed program activities.

Water construction activities; e.g., for compensating works and aids to navigation, could adversely affect local benthic communities and later recruitment to the areas. Losses of organisms would occur in each individual case, but this impact is perceived as not being significant, due to the short duration and temporary nature of the disruption.

Impacts on Vegetation

Significant impacts of the proposed program on vegetation appear unlikely over large areas of the Great Lakes System, but impacts could occur within constricted areas of the system, such as in connecting channels.

Icebreaking and vessel operations in constricted areas of connecting channels could result in the lateral and vertical movement of ice adjacent to shorelines. This ice movement could disrupt shoreline, littoral zone and wetland vegetation. Wetland areas that are susceptible to this ice movement are in Sturgeon Bay, Grand Traverse Bay, and the St. Clair River delta. Significant alteration of wetlands in these areas could have far-reaching effects on the wildlife, fisheries, and primary productivity of the area; i.e., the food chain.

Changes in ice cover due to icebreaking and vessel passage could affect the primary productivity on a localized basis. Solar energy entering a body of water is used by microscopic, planktonic algae in the photosynthetic process. This energy is converted into chemical energy and stored within the organism.

Decreasing ice thickness by use of bubblers or opening of channels by icebreaking and vessel movement would allow more light to penetrate into the body of water. This could provide the energy for accelerated planktonic growth. The size of the open channels is insignificant in comparison to the surface area of the Creat Lakes. Also, the vessel tracks are normally filled with broken ice, leaving very little open water. Therefore, because a very small area would be provided for reception of this increase in available light, impacts are expected to be minor.

Construction operations could remove or adversely impact submerged vegetation. Dredging operations could eliminate areas of submergent growth. Resuspension of sediments could increase siltation on submergent leaf surfaces. Impairment of growth or death of plants could occur from retarded photosynthesis or nutrient absorbtion. Impacts could extend to the aquatic fauna of areas through the loss of habitat or food chain production.

Terrestrial

Construction of shore based aids to navigation, e.g., course ranges, would have a minimal effect on terresterial vegetation. Beneficial and adverse impacts that could occur would be dependent on site location. If the site consists of wooded vegetation, course range sties would be cleared of obstructive vegetation from the water edge to the rear of the range lights. The area affected should not exceed 100 yards in length and about 50 feet in width. Low vegetation, such as marsh grasses and cattails, would not be removed.

Loss of vegetation could also occur with the construction of required support facilities. Removal or burial of upland flora could result from individual projects. Most facilities are expected to be placed adjacent to existing facilties; therefore, impacts are perceived as being minor.

Dredging would require disposal sites. Upland disposal sites are being considered; however, disposal sites are not yet known. Terrestrial flora would be temporarily destroyed should this method be adopted, but normal succession and mitigation measures trends should provide for vegetational re-establishment and replacement. Wetland areas are not suitable for disposal site location.

Impact on the Fisheries Resource

The fisheries resource of the Great Lakes System could locally be affected through various Project activities. The Project activities in areas such as connecting channels, harbors, and shallow water areas of lakes could influence fish spawning including egg survival, behavior, distribution and habitats.

Several potential impacts to fish spawning could occur. Of particular concern are the lake herring and whitefish in Lake Superior. Eggs of these species are spawned in November-December and take about 150 days to incubate at temperatures around 39.0° - 41.0°F (4.0° - 5.0°C) with a peak temperature being 37.9°F (3.30°C). Previous to the Demonstration Program, shipping had been naturally restricted by winter conditions. Under the Winter Navigation Demonstration Program vessel operations increased in ice environments of Lake Superior and St. Marys River. Ice resistance to vessel movement could create turbulence by propeller wash in areas where vessels are drawing near maximum draft. Vessels trapped in or hindered by ice could also increase the amount of propeller wash. Redistribution of bottom sediments over active fish spawning areas could bury incubating eggs resulting in increased mortality rates. Studies are being recommended, including the sedimentation rates resulting from ice navigation, fish potential egg densities in areas of sedimentation, and determination of egg viability under the conditions encountered.

Two studies were conducted on fisheries in the Great Lakes System. The St. Lawrence River Fisheries Study was developed to help evaluate the reasonably foreseeable environmental effects of the Winter Navigation Demonstration Program on the fisheries of the St. Lawrence River. Data were collected during the winter and spring of 1979 at Morristown, Chimney Bay and Tibbits Creek, to determine the character of the St. Lawrence River fisheries in these areas. The study had two major segments; (1) adult fish sampling, which took place during the winter and spring, and (2) ichthyoplankton sampling, which took place only during the spring.

The study found species diversity to be higher at Chimney Bay and Tibbits Creek in comparison with Morristown Point. This appears to reflect the greater diversity and abundance of productive habitats for fish at the former location. Species abundance and distribution were found to vary by location, time of year, and depth of sampling, with the number and species of fish collected in gill nets generally greater in shallow water than in deep water stations. The increased adult species abundance and diversity during the spring, relative to the winter, probably reflected increased fish movement associated with spawning and feeding. The study also found ichthyoplankton abundance and species numbers to increase progressively throughout the spring. Heavier feeding for northern pike and yellow perch occurred during both winter and spring, as evidenced by stomach content analysis.

Since the fisheries of the St. Lawrence River are dependent upon a complex of additional physical, chemical, biological and sociological parameters, concurrent monitoring of additional parameters is necessary. In the absence of such data, one can only hypothesize as to the causative factors effecting changes in the river fisheries.

The study on the St. Marys River System was developed to locate the spawning grounds of the lake whitefish, Coregonus clupeaformis and the lake herring, Coregonus artedii; and to determine the amount and classification of sediments deposited over these spawning grounds. Potential and existing spawning beds were identified through interviews with local fishermen. Data were collected from February to March 1979.

Extreme difficulty was met in the recovery of eggs, which may have been due to one or a combination of factors. The population may have been low, eggs in the vicinity of the navigation channel may have been subjected to resuspension by disturbance from passing vessels (Gleason, et. al., 1979) which could increase predation and dislocation, or spawning could have been restricted to such a small area, that it was easily missed during reconnaissance.

It was found that winter navigation vessel traffic increases the amount of material suspended in the river as much as fifty fold. This information was gathered during a winter which saw minimum entrapment and reduced amount of heavy icebreaking. It was also found that normal spring breakup caused more resuspension of material than vessel passage.

It will be necessary to determine the effects of natural sedimentation on the eggs as well as the effect on vessel induced sedimentation. If the eggs are more susceptible to sedimentation during early stages of development, winter navigation may be a factor in mortality rates.

The Burbot (Lota lota) could also be affected, as discussed above. The Burbot spawns from November to May over sandy or gravel bottoms, one to four feet deep. Gravel shoals in five to ten feet of water may also be used. The young appear in as little as 30 days, usually from late February to June.

The Lake Sturgeon (Acipenser fulvescens) spawns from early May to late June. Spawning migrations generally occur after spawning rivers are ice-free. However, migrations have been known to occur under ice. The lake sturgeon spawns in depths of 2-5 feet in areas of swift water or rapids. In the lower Great Lakes, where suitable spawning rivers are not available, sturgeon have been known to spawn in wave action over rocky ledges or around rocky islands.

The Detroit and St. Clair Rivers have been identified as lake sturgeon spawning rivers. The Peach Island shoal in the Detroit River is of particular concern, because of the proposed compensating works (construction and operation). If the Peach Island shoal is significantly used for lake sturgeon spawning, implementation of the compensating works activity is perceived to possibly affect the lake sturgeon. Further detailed studies would be required prior to construction of the compensating works to evaluate this potential effect.

Spring spawning fish (e.g., Northern Pike, Esox lucius) could be affected by water levels and ice conditions. Lower water levels during the spring could cause a decrease in available spawning areas in shallow waters, which the pike requires. As discussed in the Levels and Flows Section, water levels in connecting channels could be impacted by ice control structures, compensating works, and vessel operations. Modification of ice cover could impede spawning migration by creating a physical barrier. This barrier could prevent or alter the access to spawning areas.

Fish migration could also be affected by bubbler systems. It has been theorized that long-line bubblers could interfere with fish migration should some species refuse to cross the "air-curtain" generated.

Habitat

Potential changes in fish habitats could occur from a variety of project-related activities, which include vessel operations, propeller wash, addition of riprap, dredging, dredge material disposal, construction of navigation aids, compensating works, and icebreaking.

Vessel operation and icebreaking have potential to disrupt nearshore habitats; i.e., wetland fringes such as those in the St. Clair River and shoals of Bois Blanc, Round, and Mackinac Islands, and those adjacent to the channels of Saginaw Bay, Alpena Harbor, Sandusky Bay, Peach Island, and Grosse Ile (St. Clair and Detroit Rivers).[10] Bottom areas used for feeding, cover, and predation could also be physically disrupted. This could impact the overall fishery resource of the affected areas, both commercially and recreationally. It is not currently possible to quantify this potential impact.

Propeller wash and vessel movement could increase turbidity and suspended sediments. Increased turbidity could influence sight-feeding species, such as bass and pike, by decreasing their range of vision. Siltation of resuspended sediments could eliminate submerged vegetation habitats used by fish for feeding, cover, and resting areas. Gravel spawning beds could also be buried by this sediment if any are located where sedimentation would be increased.

The use of riprap for shoreline protection and in water structure protection could alter the aquatic habitat. Initial placement of

[10]U.S. Department of the Interior, Fish and Wildlife service, Fish and Wildlife Report - Draft, 1978.

riprap or other similar material would eliminate some benthic habitat, but new habitats would be created. These "new" habitats would arise from the increased surface area of the riprap and the interstitial space between individual components of the riprap. The additional surface would provide a base for primary productivity, the base food source of the food chain. The spaces established would be available to young fish as protective cover and feeding areas.

Dredging could result in a significant alteration of fish and benthic habitats. Included would be shoreline areas, aquatic vegetation, and spawning habitats (i.e., shoals). Turbidity would be temporary, dispersing some nutrients to the surrounding waters. After a short length of time, water conditions should return to background levels. Some shallow water areas would be deepened.

Disposal and construction activities in shoreline and open water areas would cause a loss of habitat. Dredge material disposal sites are not yet known. Separate environmental documents for each individual project could be required.

Impact on Wildlife Resources

Wildlife within the Great Lakes Basin could be impacted by a Navigation Season Extension Project. These impacts would occur in the coastline area where the project-related activities occur. As previously mentioned, the areas of perceived major impact are the shoals, littoral zones, and coastal wetlands of connecting channels and harbors which are all valuable habitat.

Migration of mammals that use ice cover for crossing water barriers could be affected under the proposed program. The opportunity for mammals to cross water barriers could be important in influencing the distribution of species of mammals by permitting

range expansion into favorable habitats; and the accessibility of seasonal resources such as food or shelter for a mobile population. Mammals cross water barriers either by swimming, rafting (floating on logs, etc.) or by walking on ice. For mammals which are active in the winter, the latter is probably the most important means of travel.

In the eastern Lake Superior-St. Marys River area wolves (*Canis lupus*), coyotes (*C. latrans*), foxes (*Vulpes fulva*), lynx (*Lynx canadensis*), bobcats (*L. rufus*), moose (*Alces alces*), deer (*Odocoileus virginianus*) and probably several other smaller mammals use ice as a means of transportation. The eastern timber wolf, designated as an endangered species in the United States, has been maintaining very small populations in Michigan's Upper Peninsula. It is believed that most of the wolves are immigrants from Ontario to the east and possibly from Minnesota to the west. Wolves have been seen occasionally crossing to Michigan from Ontario on the ice of Whitefish Bay. There is practically no quantitative data available on the extent to which mammals use the ice of eastern Lake Superior and St. Marys River which results in species dispersal.

A study conducted on the effects of winter navigation on the St. Lawrence River indicated that the maintenance of an open channel would alter the use of the ice by shoreline mammals, particularly the red fox and coyote, which extend their home range during frozen conditions, to compensate for the seasonally low availability of prey. The study also indicated that species density on offshore islands could also decline due to restrictions in over ice movement.

Wildlife breeding could be affected by the proposed program through the loss of breeding habitat. Construction activities, dredging, and vessel operation could eliminate, degrade or enhance the breeding value of certain areas. Of main concern are emergent

wetlands that could be impacted by the above activities. Muskrats and numerous species of waterfowl and shorebirds utilize these areas. The muskrat could be impacted by bottom and wetland edge disturbance from ship passage or modification of habitat through water level fluctuation. Also, the Fish and Wildlife Report (Appendix I) stated that vessel speed could have a profound effect on wildlife and fishing resources in various parts of the basin.

Various aquatic wildlife habitats throughout the Great Lakes could be impacted to some extent by the proposed program. Areas such as emergent wetlands and shoals are perceived as vulnerable to many of the proposed activities that would occur if the plan is implemented as described. A variety of waterfowl and shorebirds, as well as mammals such as muskrats, raccoons, and mink, utilize these areas for feeding, resting, and migration. Loss or alteration of these important habitats due to physical changes by the project activities could lead to decreased production. This could, in turn, affect the ecology and economics of nearby areas by decreasing the number of organisms present which could decrease trapper catches, for example. Secondary effects would need to be identified, and total impacts quanitifed if possible.

Open water may be created or modified by icebreaking activity associated with the program, which includes U.S. Coast Guard icebreaking activities and commercial vessel traffic in an ice environment. Broken ice fields also occur by natural means, which can yield brash and pack ice. Icebreaking activity associated with winter navigation in conjunction with natural broken ice fields could aggravate ice conditions in restricted water environments.

Winter waterfowl habitat has been increased over the past 20 to 50 years due to warm winter discharges from urban and industrial developments along portions of the St. Clair River. In those

portions where ice packs have become static and have knit together under undisturbed conditions, warm water discharges can create openings in shallow and productive reaches of the river adjacent to banks. It is these open, shallow, and productive reaches which serve as feeding areas for wintering waterfowl on portions of the St. Clair River. Over the years, populations of waterfowl have developed which winter in these open areas, and these birds no longer migrate further south. Many generations of this altered migrating population have passed, and a large flock has developed. It is doubtful that these birds could be influenced to re-establish their normal southern migration habitats.

It has been reported by the Michigan Department of Natural Resources (MDNR) that the above created winter feeding areas have, at times, become severely restricted or reduced in size, due to efforts to extend winter vessel traffic. Vessel traffic, as reported by MDNR, could aggravate ice conditions by breaking the static ice packs and cause continual encroachment of ice packs into the winter feeding areas, thereby reducing the available feeding area. It is this restriction to waterfowl usage that, over a period of time, would cause malnutrition in waterfowl.

One such case has been reported by the MDNR on the St. Clair River.* Approximately 50 dead ducks (canvasback, redhead, lesser scaup, greater scaup, goldeneye, white-winted scoter, mallard, and coot) were retrieved from along the shore between Marine City and St. Clair, Michigan. Most of the birds examined showed evidence of malnutrition as the cause of death. In addition, many live ducks observed along the shoreline were in very poor physical condition, probably due to malnutrition resulting from restrictions in waterfowl habitat.

* MDNR - Interoffice communication - Status of Wintering Canvasback Population on St. Clair River, February 1976.

Upland habitats could be affected through construction activities of shore facilities and land-based navigation aids which could alter or eliminate small shoreline areas. These changes could cause the displacement of some fauna to neighboring areas. The clear cutting of vegetation for navigation aid courses would establish a diversity of habitats within a short distance. This area, called an ecotone (a transition or buffer zone), would become available for colonization by other organisms. Addition of this type of area could be considered favorable, depending on the site location. Winter for many birds and terrestrial mammals is a critical period. Metabolic demands created by low temperatures, winds, and frequent scarcity of food contribute to physiological demands which may be reflected in direct mortality or reduction of reproductive success in the succeeding spring. These stress situations arising as secondary impacts of altered terrestrial and aquatic habitats could result in malnutrition and related diseases due to weakened condition.

Impact on Endangered or Threatened Species

Endangered and threatened species could exist in the areas of proposed activities. The Federal Register of the List of Endangered and Threatened Wildlife and Plants (Jan. 17, 1979) cites the following as occurring within the Great Lakes Basin:

Common Name	Scientific Name
Wolf, Gray[1]	*Canis lupus*
Bat, Indiana	*Myotis sodalis*
Bat, Gray	*Myotis grisescens*
Falcon, American Peregrine (migratory only)	*Falco peregrinus anatum*

[1]Threatened in Minnesota, Endangered in Ill, Ind, Mich, Ohio & Wisc

Common Name	Scientific Name
Falcon, Arctic Peregrine (migratory only)	Falco peregrinus tundrius
Eagle, Bald[2]	Haliaeetus leucocephalus
Warbler, Kirtland's	Dendroica Kirtlandii
Pike, Blue	Stizostedion vitreum glaucum
Madton, Scioto	Noturus trautmani
Cisco, Longjaw	Coregonus alpenae
Sampson's pearly mussel	Epioblasma (-Dysnomia) sampsoni
White cat's eye pearly mussel	Epioblasma (-Dysnomia) sulcata delicata (including perobliqua)
Tuberculed-blossom pearly mussel	Epioblasma (-Dysnomia) torulosa torulosa
Higgin's eye pearly mussel	Lampsilis higginsi
Pink mucket pearly mussel	Lampsilis orbiculata orbiculata
Fat pocketbook pearly mussel	Potamilus capax
Rough pigtoe pearly mussel	Pleurobena plenum
White warty-back pearly mussel	Plethobasis cicatricosus
Orange-footed pimpleback mussel	Plethobasis cooperianus
Northern wild monkshood[3]	Aconitum noveboracense

Both the American peregrine falcon and the arctic peregrine falcon are migratory species in this area. Since there are no known falcon nest sites in the project area, the proposed extension of the activities of the locks should have no effect on these birds.

[2]Threatened in Minnesota, Wisconsin & Michigan. Endangered in Ohio, Illinois, and Indiana.

[3]Threatened

Recent studies have identified two bald eagle perch areas along the northeast shore of Sugar Island in the St. Marys River. The study by Dr. W. Robinson states that it appears that shipping has no positive impact on the eagle, but may have a minor negative impact by causing the eagle to shy away from the vicinity of ship traffic. This may temporarily restrict space for the eagles and cause additional expenditures of energy by the birds when flushed during ship passage. Indirect effects include the influence of ship-caused turbidity and scouring on vegetation used as duck food, (in turn, eagle food) and the potential spillage of oil or toxic material, injurous to water related birds, during shipping.

A study conducted on the St. Lawrence River also observed bald eagles in the navigation corridor. These eagles were present in the study area until 7 March, and were found to more heavily utilize pools in shallow, more productive waters, than the pools in deep water channel areas. Field observations and scientific literature indicated that the proposed winter demonstration program (for FY79) may affect bird behavior, distribution, and abundance. Disturbance by ships and monitoring efforts, alteration of the open pools and indirect effects on food sources may all have significant negative impacts.

During the winter of 1978-79 the Michigan Department of Natural Resources (MDNR) undertook the first mid-winter bald eagle survey in the state of Michigan. The survey was initiated at the request of the National Wildlife Federation Raptor Information Center as part of the National Wildlife Federation coordinated continental mid-winter bald eagle survey. The results of this survey are to be used by MDNR to help monitor the health and well-being of the eagles and help to insure their continued presence.

The bald eagle, a threatened species in Michigan, is more numerous in the Great Lakes states than in the rest of the continental United States.

Last year, an MDNR summer survey of the bald eagles found 83 nesting pairs in the state, mostly in the Upper and northern Lower Peninsulas.

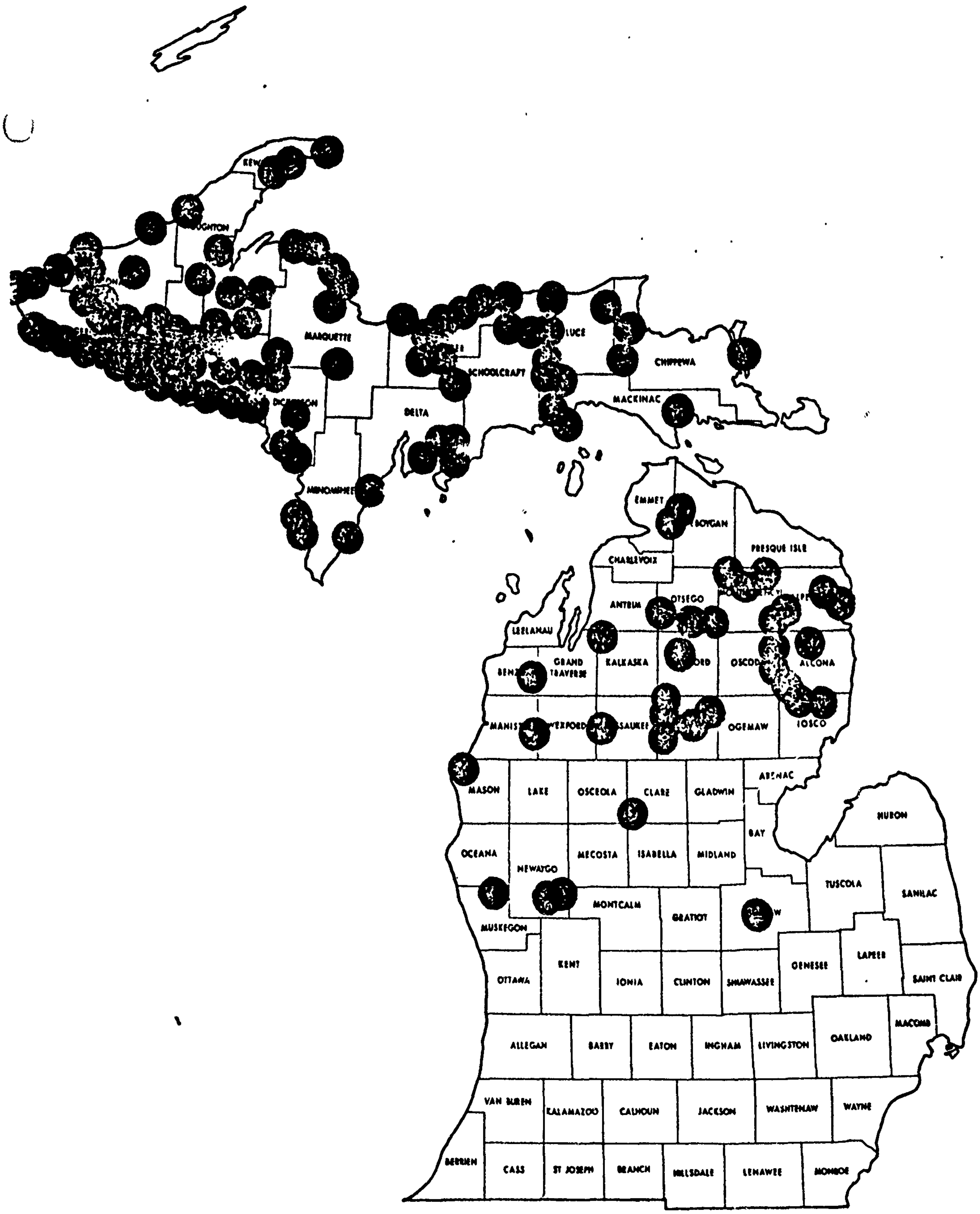
The survey conducted during the period of January 13-27, 1979, yielded the following results:

	BALD EAGLES		GOLDEN EAGLES	
	adults	immatures	adults	immatures
Region I	11	1	0	0
Region II	13	1	0	0
Region III	3	1	1	1

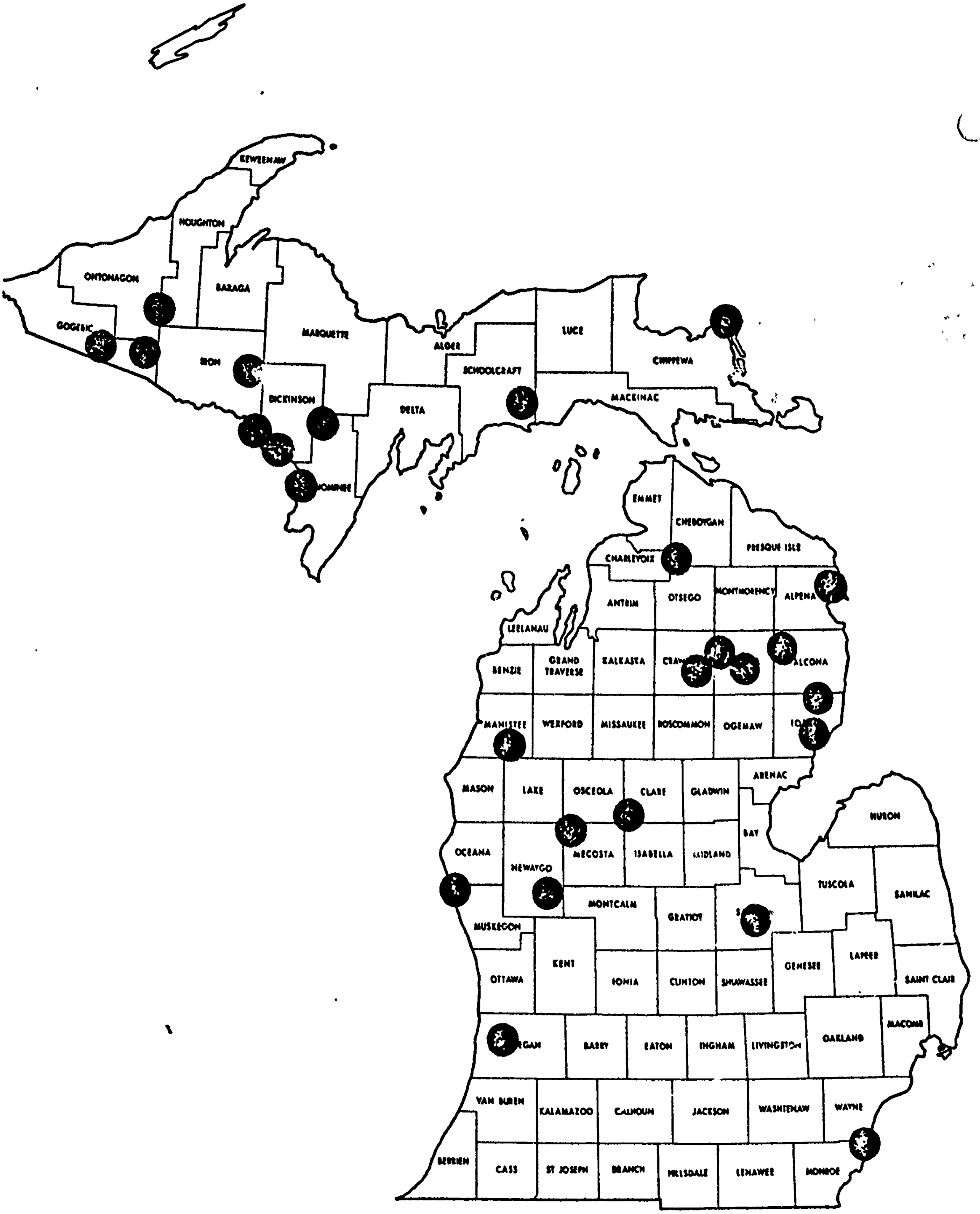
Survey results showed that most eagles wintering in Michigan are adults. Fish, waterfowl, and highway-killed deer are their major food sources during the winter. Throughout the survey, many eagles were found near large, open water areas.

The following maps show the locations of bald eagle nests and winter observations of eagles in the state of Michigan, as determined by MDNR survey.

The protection of threatened and endangered species falls under several Federal laws. One such law is the Endangered Species Act of 1973, amended in 1978. Section 7 of this act states that Federal agencies are required to develop a biological assessment on construction projects to determine the species that are present in the project area. Formal consultation with the Fish and Wildlife Service (FWS) must be completed before any permits are granted and the project is implemented.



BALD EAGLE NEST SITES



WINTER OBSERVATIONS OF BALD EAGLES

Another law concerning protection of threatened and endangered species is the Act for the "Protection of Bald and Golden Eagles" (16 U.S.C. 668-668d) and the regulations that have been derived therefrom (Title 50, Code of Federal Regulations). The Act states, in part, that no person "Shall take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or in any manner, any bald eagle commonly known as American eagle, or any golden eagle, alive or dead, or any part, nest, or egg thereof of the foregoing eagles..." The act further states that "...take includes also pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, or molest or disturb..." (16 U.S.C. 668c). Whoever violates any part of the Act could, under certain conditions, be fined up to $10,000 and imprisoned for two years.

Individual states have established their own lists for endangered and threatened species or are presently formulating such a list. The following are the sources for those lists from the states bordering the subject project area.

Illinois	Endangered and Threatened Wildlife - Pamphlet Proposed for State Endangered Status - Plants, 1978.
Indiana	Non-game and Endangered Species Conservation - A Preliminary Report, 1978.
Michigan	Michigan's Endangered and Threatened Species Program, Dept. of Natural Resources, 1976.
Minnesota	Same as Federal list.
Ohio	Ohio's Endangered Wild Animals, Publication 316, (R-1078).

New York Endangered, Extirpated and Extinct Wildlife of New York State Protected Native Plants.

Pennsylvania Pennsylvania's Endangered Fish, Reptiles, and Amphibians; others protected according to Federal listing.

Wisconsin Endangered Animals in Wisconsin (With Supplementary Lists of Threatened Animals, Animals with Watch Status and Extirpated Animals, May 1978).

The EPOA recommends that a system-wide study be conducted on endangered and threatened species and their critical habitat. Existing data would be compiled and additional field work performed. Further investigation would take place where proposed activities may require an environmental document.

Impact on Noise

The level of sound (noise) is an important indicator of the quality of the environment. Ramifications of various sound levels and types could be reflected in health (mental and physical) and/or aesthetic appreciation of an area. A sound is determined to either be acceptable or unacceptable depending on the loudness and duration. Various guidelines and regulations have been established at Federal and State levels showing this comparison. The Occupational Safety and Health Administration (OSHA) has provided general acceptability guidelines for various noise levels. These are listed, in part, below:

Duration (hrs)	Loudness (decibles-dBA)*
8	90
4	95
2	100
1	105

* These dBA numbers bear a logrithmic relationship

The Environmental Protection Agency has evaluated that 70 dBA over a duration of 24 hours could cause partial, if not total hearing loss.

Activities associated with the Winter Navigation Program, such as construction, dredging, icebreaking and vessel operations would cause some level of noise.

Construction operations associated with the project would create noise through the use of vehicles, construction equipment and power tools. This noise affects the operators, personnel, communities near the site, and the people near transportation routes to the site. Sound generated by construction operations would be temporary in nature. The significance and magnitude of the impact is dictated by the location and time of occurrence of the actual operation. Construction operations in residential areas could be of greater magnitude and environmentally less acceptable than for a similar operation in an industrial area. Federal, State and local regulations and codes, as well as restrictions imposed on the operational time period, would assist in mitigating any potential adverse noise impacts in affected areas. If necessary, restrictions would be imposed on a case by case basis.

Dredging and its related disposal activities also have associated operational noise levels. Again, the level of significance is related to the area and the time period that such an operation would take. Measurements conducted by the Corps of Engineers during dredging operations of the type that could be employed for this proposed extended navigation program showed that an average decible (dBA) reading of 80 can be expected 100 feet from the operation. For comparison, a busy office can obtain the same level of sound (80 dBA) and a quiet residential neighborhood has been recorded at 40 dbA.[11]

Icebreaking and commercial vessel operations would create a significant increase in noise during times where historically navigation ceased in winter. Even though operations would occur in the early winter months, the introduction of physical impacts year-round could be of concern. The magnitude of this impact on the adjacent areas would depend on the nature of the areas themselves. Sound generated by shipping operations in a harbor environment, during the winter, would not be greatly different than that of the summer months. Installation and operation of ice suppression equipment (e.g., bubblers) would be a source of sound generation. However, it is expected that the normal background noise level of daily harbor operations would tend to mask these anticipated sounds. Shipping activities in riverine sections of the waterway would be of contract to former inactive winter months. Because of the general seasonal residential nature of these shoreline areas, it is expected that this characteristic would minimize the magnitude and environmental significance of the proposed operations.

[11]Althouse A.D., Turnquist, C.H., Bracciano, A.F., 1975 Modern Refrigeration and Air Conditioning, Goodheart - Wilcox Co., Inc.

Overall, noise problems are complex since they depend on distance, wind, weather, and the particular listener. While it is possible to identify and quantify sounds attributable to various operations, it is difficult to predict the subjective interpretation in a given location under varying conditions. Impacts are expected to be of a low nature due to the reasons stated above.

Impact on Energy

In order to determine the energy impact of extending the navigation season on the Great Lakes/St. Lawrence Seaway (GL/SLS), an Energy Impact Study was conducted, refer to Appendix D. Specifically, this study compared the energy consumption associated with winter waterborne movement of bulk and general cargo during an extended navigation season to the energy consumption associated with winter movement of the same commodities via the least-cost alternative transport mode (rail, truck, barge). All line haul movements were specified as origin to destination movements shipped either via a GL/SLS routing or an alternative transport mode routing. The analysis measured the change that extended season navigation would have on the energy, consumed in line haul freight operations as a result of: (1) traffic being diverted to the GL/SLS system from alternative transport modes, and (2) Great Lakes traffic being redistributed from the normal season to the winter season as a result of altered stockpiling patterns. Included in the analysis were the increased transit times and delays that would be associated with winter navigation operation for the various size vessels in the Great Lakes and overseas fleets, as well as the energy expended by the facilities and operations required to support winter navigation. The results of the Energy Impact Study indicate that there would be a small, but positive, energy savings associated with the increased GL/SLS waterborne movement that would result from an extended navigation season (Table II-3). Conservation assumptions taken

TABLE II-3
SUMMARY OF NAVIGATION SEASON EXTENSION ENERGY IMPACTS
(billions of Btu's per year)

ENERGY IMPACT AREA	1990	2000	2010	2020	2030
Normal Season Line Haul					
GL/SLS	58,753	64.416	67,677	70,350	72,795
Alt. Transport Mode	500,851	748,822	1,062,939	1,409,263	1,772,418
Total Norm. Seas. Line Haul	559,604	813,238	1,130,616	1,479,613	1,845,213
Extended Season Line Haul					
GL/SLS	59,936	72,623	87,800	90.986	93,934
Alt. Transport Mode	498,955	739,705	1,041,522	1,387,092	1,749,3i3
Total Ext. Seas. Line	558,891	812,328	1,129,402	1,478,078	1,843,247
Net Line Haul Savings	713	910	1,214	1,535	1,966
Less Infrastructure					
Energy Use:					
Ice Breakers	373	459	459	459	459
Air Reconnaissance	21	21	21	21	21
Bubblers	59	59	59	59	59
Local Tugs	8	34	80	78	79
Tugs at Locks	99	99	99	99	99
Semi-Permanent Ice Controls	38	38	38	38	38
Other Associated Impacts	52	52	52	52	52
Total Infrastructure Costs	650	762	808	806	807
Net Energy Savings	63	148	406	729	1,159

throughout this study on energy consumption were based on severe winter conditions and the nearest or least circuitous ocean port for transshipment overseas.

For a detailed account of these findings, please refer to Appendix D.

In addition, Appendix I contains a detailed discussion on the effects of winter navigation on levels and flows in the Great Lakes/St. Lawrence Seaway System. As far as the impact of winter navigation on power production is concerned, Table I-7 of Appendix I provides the 1960-1976 dollar benefits/losses to hydropower, based on theoretical extreme ice conditions (0 percent ice retardation and 200 percent ice retardation) for 10 and 12 month extended navigation seasons. As stated in Appendix I, the expected ice condition with the proposed plan of improvement in operation is expected to be less than 100% ice retardation, which might, if properly exploited, provide dollar benefits to power due to increased Lake Erie outflows.

Discussion of Environmental Assessment for FY79 Demonstration Program (Prepared by New York Department of Environmental Conservation)

In July 1978, the Corps of Engineers circulated to all known interested parties copies of "Environmental Assessment FY 1979 Winter Navigation Demonstration on the St. Lawrence River." This study, funded by the Corps of Engineers, was done by the New York State Department of Environmental Conservation in conjunction with the State University of New York. The summary section of this report predicted impacts of serious environmental consequence, and the NYDEC Commissioner, Mr. Peter A.A. Berle, called for disapproval of the proposed demonstration in the St. Lawrence, irrespective of its final design. The demonstration was subsequently cancelled for a number of reasons, including lack of sufficient information.

A number of agencies provided comments to the Corps on this assessment of impacts, and these comments were circulated to the public in the Final EIS for the FY 1979 Demonstration Program. Most respondents favored continuing the program.

The St. Lawrence Seaway Development Corporation commented that the assessment was based on inaccurate assumptions concerning engineering aspects and stated that substantial discrepancies existed between the technical reports and the summaries. The SLSDC basically concluded that the NYDEC conclusions of unacceptable impacts were not justified by the facts or the technical reports. The U.S. Coast Guard concluded that the tests should be conducted and questioned "Is a less than significant adverse impact acceptable?" (In a later meeting of the Winter Navigation Board, when the decision was pending of whether or not to conduct a demonstration, a representative of the New York Dept. of Environmental Conservation stated that no impact on water levels was acceptable.)

The U.S. Environmental Protection Agency stated that the potential for adverse environmental effects of dredging appeared to be minimal. It also found that information presented supported selection of the test site, except for concern over the Bald Eagle, and withheld a recommendation pending the final engineering data, the Endangered Species determination, and the results of the public meetings. The U.S. Fish and Wildlife Service found that a revised draft EIS which clearly documented impacts was required, indicating that the impacts should first be quantified. The FWS, at a later date, determined that the proposed tests would not jeopardize the continued existance of the Bald Eagle within the meaning of the Endangered Species Act. The Maritime Administration generally disagreed with the assessment, pointing out numerous inconsistencies and stating "the viewpoint expressed appears to be parochial in nature" (concerning economic considerations). MARAD recommended conducting the tests.

The National Oceanic and Atmospheric Administration commented "that the effects of the modest demonstration program proposed for the St. Lawrence River would have minimal impact on the environment." The Department of Natural Resources of the State of Wisconsin stated that NYDEC's calling for disapproval was premature and recommended that the Demonstration Program continue. The Department of Environmental Resources of the Commonwealth of Pennsylvania stated that the report did not contain sufficient information to adequately justify conclusions, recommending that the program be carried out. The Toronto Harbour Commissioners believed that statements concerning ice jamming and water level consequences supported Mr. Berles' conclusion, but thought the tests should be done following further study of boom modifications and operational techniques.

It should also be noted, as addressed in Appendix I, that the Corps, after further studies, found that the predicted impacts on levels and flows were substantially greater than what should actually be expected. The assessment and levels and flows predictions remain controversial.

SECTION F-III

POTENTIAL IMPACTS OF THE EXTENDED NAVIGATION SEASON ON HISTORICAL AND CULTURAL RESOURCES

Introduction

This section presents the results of an inventory search of cultural resource records and literature in the states adjacent to the Great Lakes, their connecting waterways and the St. Lawrence Seaway. In each State only those areas in and adjacent to specified harbors, as well as connecting channels, rivers and the Seaway were investigated. Specifically, harbors shown on Figure III-1 on the coasts of Minnesota, Michigan, Wisconsin, Indiana, Illinois, Ohio, Pennsylvania and New York were the focus of this effort. The St. Marys, St. Clair, Detroit and St. Lawrence Rivers were also included.

The purpose of this study was to identify known archaeological, historical and paleontogical resources which might be impacted by activities related to the proposed extended navigation season on the Great Lakes. Further, where possible, an attempt has been made to anticipate potential impacts, recognizing the general lack of site specific locational data. The problem will be discussed on a State by State basis since there is considerable variation in the quantity of site data available in each State.

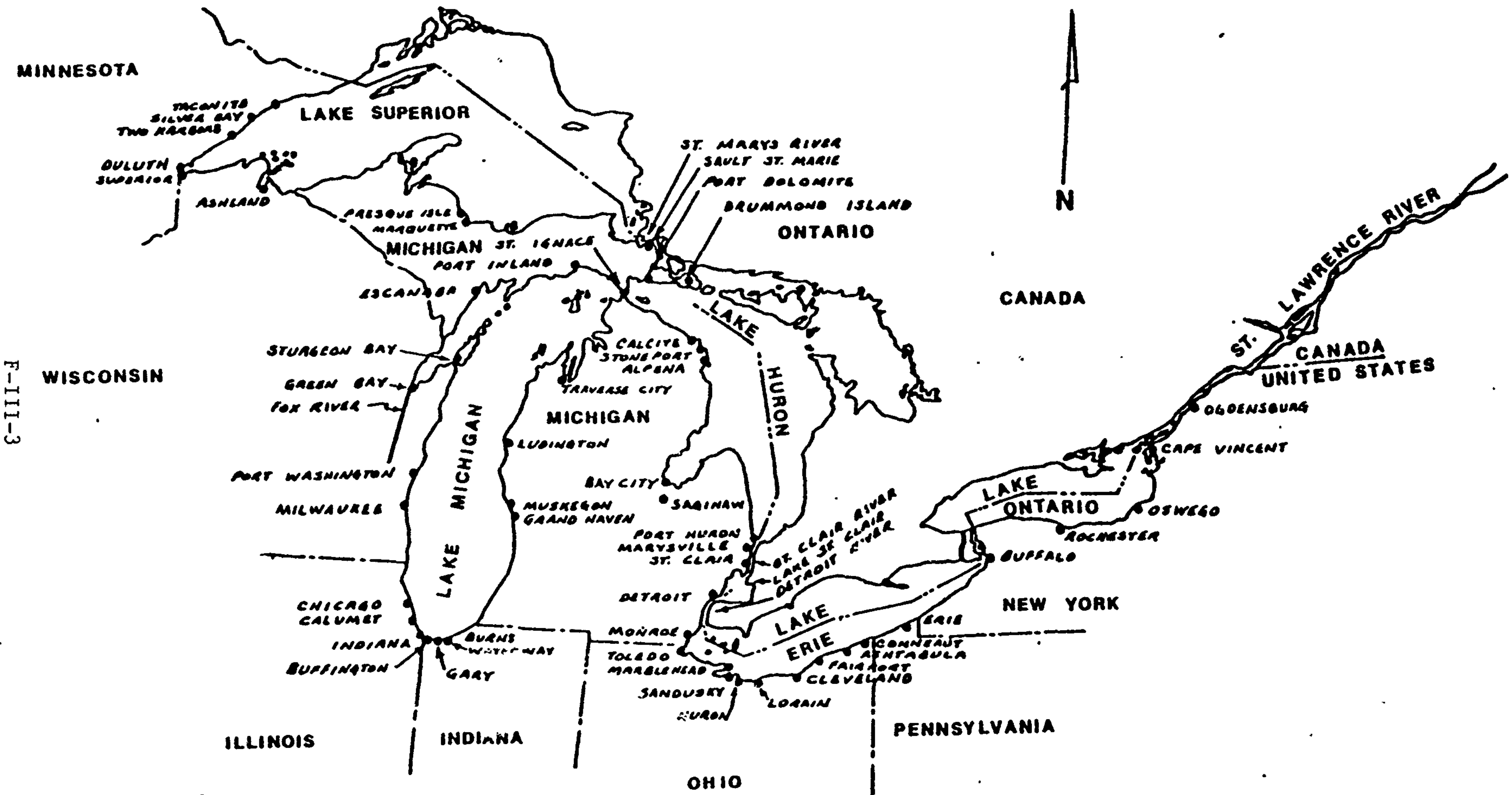
In addition an attempt has been made to determine the number and concentrations of ship wrecks which could also be impacted by the extended navigation season activities. The mass of ship wreck data, unreliability of locational data, (except in a very few instances) and the time limits of this report have combined to make that section a more generalized discussion. There are two examples of the number and nature of ship wrecks associated with specific harbors. There is a need to intensify this part of the investigation should the project be authorized.

The following personnel were assigned to undertake the inventory by states:

Minnesota - David Barton
Wisconsin - Randall Guendling
Illinois - John Claflin
Indiana - Keven Crouch
Michigan - John Dorwin and Richard Vanden Heuvel
Ohio - Jeffrey Myers
Pennsylvania - David Sonner
New York - David Sonner

It was decided to handle ship wreck data separately from the archaeological and historical sites and structures. Thus these are presented in a single chapter. Comments relative to ship wrecks are, however, contained in some of the harbor summaries.

The basic intent of this section is to provide cultural resource locational information where possible and a generalized state of the inventory in each State. The study evaluates impacts where possible and presents an overview of the work remaining to be accomplished in post authorization studies should the project be authorized.



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• COMMERCIAL HARBOR AND/OR ICEBREAKER PORT

FIGURE III-1 GREAT LAKES · ST LAWRENCE SEAWAY REGION

Archaeological and Historical Perspective

The appearance of people in the New World is generally agreed to be the result of migration across the Bering Sea during the late Pleistocene--a movement made possible by the same glaciation (Wisconsin) that is responsible for the creation of the Great Lakes. These were the ancestors of the Native Americans. Although there is a considerable body of opinion holding that the initial wave of migration occurred as early as 60,000 years ago, the earliest entry date for which hard evidence exits is approximately twelve to thirteen thousand years before Christ. The variability of physical traits within the New World populations has led to suggestions that it was the result of several waves of migration. The extent to which this variability can be attributed to different migrations is uncertain. Given the impacts of environmental adaptation and genetic drift, it is generally agreed that at least two waves of migrations did occur. The second wave, considered to have been between 5000 and 6000 years ago, is thought to represent the ancestors of the current Aleut populations.

Paleo-Indian Traditions

Whatever date of entry is accepted, the earliest identifiable cultural tradition in the New World is known as Paleo-Indian. Dated to as early as 15,000 years Before the Present (BP), this pattern is largely considered to have developed primarily in the North American High Plains from whence it spread and adapted to other regions. Within the current Great Lakes Basin, this period is concurrent with the retreat of the Wisconsin ice sheet. As the boreal forest that covered most of the area immediately south of the glacier provided relatively little in the way of either game or plant foods, these hunters exploited those areas uncovered by the glacial retreat. The early successional vegetation found in such peri-glacial areas supported the type of large grazing animals that fueled the subsistence of the tradition. Scattered archaeological sites on the upper

Great Lakes (e.g., the Brohm site on the north shore of Lake Superior) suggest that some descendants of this early Paleo-Indian tradition followed the habitat created by the retreating ice as it moved northward.

As outlets for the immediately post-glacial Lake Algonquin were formed, late Paleo-Indians exploited the shoreline area which, in a primarily forested area, had more available food production. It is suggested that while late Paleo-Indians remained primarily dependent upon hunting for subsistence, they had adapted to the forest environment and therefore were oriented toward smaller game animals. The refilling of the lake basins after the Chippewa-Stanley low stage (ca. 7500 B.C.) flooded the habitat utilized by these peoples and essentially represents the end of the Paleo-Indian Tradition in the Great Lakes region.

Archaic Tradition

Throughout the continent, the Archaic Tradition is considered to represent the development of a subsistence pattern exploiting a wide range of food sources and uniquely fitted to the regional ecosystem. Implied in this fit is the development of subsistence bases with cyclical, seasonal emphasis. The developent of the Archaic Tradition, then, represents attachment to a region and its resources rather than the nomadic pursuit of a single resource.

Within the Great Lakes region, however, the Archaic Tradition is represented by only a few sites prior to 3000 B.C. In Michigan, for example, no large, permanent Early or Middle Archaic sites have yet been found (Fitting, 1975).

With the advent of the deciduous forest, came the establishment of a biotic community considered to be more amenable to direct human exploitation. The return of high water levels in the Great Lakes may also have helped to create additional food sources through lessening of stream gradients, the resultant slower streams being generally more productive.

The Late Archaic Tradition represents a time of increased human occupation over the entire northeast portion of North America, and a time of a great deal of cultural similarity across the entire continent. The emphasis of Archaic cultures on adaptation to a specific set of environmental circumstances led to the establishment of the Eastern Woodlands as a distinct cultural unit for the first time. Perhaps the most important technological innovation associated with the Archaic period is the appearance of pecked, ground and polished stone tools. It was during the Late Archaic period that peoples of the upper Great Lakes region first began extensive use of the copper found there. Mined in the Lake Superior area, this copper gained distribution over the entire Great Lakes Basin.

Woodland Tradition

The transition to the Early Woodland phase is dated from the initial appearance of pottery in the eastern part of North America. For the most part, subsistence strategies followed Archaic patterns, with the important exception of the use of cultigens. Including squash, gourd, sunflower, marsh elder, and chenopodium, these cultigens are considered to represent additions to the subsistence pattern rather than a new subsistence emphasis.

Definition of the Middle Woodland period is based primarily upon the time of domination of the Hopewellian culture roughly between 200 B.C. and 400 A.D. Hopewell appears to have developed and evolved not far south of the Great Lakes Basin, and spread to cover approximately the southern half of the region. Perhaps the most striking feature of the Hopewellian culture is the development of elaborate burial practices and the massive mounds which resulted. The large scale trade networks established during this period are believed by some to have been the result of the desire for exotic goods used in the burial context. These networks appear to have extended over the bulk of the North American continent. It has also been suggested that the Hopewell culture was almost entirely based on agriculture.

The dominant Middle Woodland Tradition established in the northern portion of the basin has been termed the Lake Forest Middle Woodland. This tradition is characterized by reliance on fish as a major portion of the subsistence base. These people maintained large summer villages primarily dependent upon fishing, while breaking down into extended family winter camps that relied mainly on hunting. Although there is little evidence of the relationship between the Lake Forest and Hopewell cultures, there is evidence that a trade relationship existed.

The transition from Middle to Late Woodland traditions is dated approximately 500-600 A.D. and is marked by the decline of the Hopewellian culture. The Lake Woodland period is perhaps most distinctively marked by the development of an agricultural base in the southern portion of the basin. This led to the development of more and larger settlements in the agricultural region, while a regional trade network evolved to allow the distribution of those agricultural goods. This trade allowed further specialization and centralization in the northern portion of the basin, resulting in a regional symbiotic relationship and more efficient utilization of the resources of the upper portion of the basin.

These developments were roughly concurrent with the development of the Mississippian Tradition in the central Mississippi River Valley, which represents the apex of prehistoric culture development in the Midwest. Population size and density in the Mississippian area were much higher than in the Great Lakes Basin, and there is evidence that a small amount of trade occurred between Mississippian centers and the Great Lakes.

Historic Indians of the Great Lakes

The dominant Indian groups in the Great Lakes Basin around 1600 A.D. were the Miami, Fox, Sauk, Winnebago, Menomini, Chippewa, Huron, Ottawa, Potawatomi, and various Iroquois tribes. To a great extent, the

subsistence patterns employed by these peoples before the disruption resulting from European contact were reflective of the symbiotic adaptations developed during the Middle and Late Woodland period.

The Chippewa dominated the upper Lake Michigan and Lake Huron basins, as well as the entire Lake Suerior basin. Estimated to have numbered between 25,000 and 35,000 the Chippewa peoples exhibited a primarily northern subsistence pattern. Those living north of Lake Superior practiced no agriculture, relying entirely on hunting and fishing and supplementing game with agricultural products gained by trade with peoples to the south. Further south, Chippewa groups practiced limited agriculture and wild food plant collection, but these are believed to have been marginal activities in their subsistence economy. During the summer, the Chippewa gathered in large groups where the fishing was good, while in the winter the large groups spread out in extended family units and relied on hunting.

The Potawatomi and Ottawa were culturally similar and, before the territorial perturbations induced by European contact, occupied between them most of Michigan's lower peninsula. The Ottawa additionally occupied territory in the Georgian Bay area of Lake Huron. Both groups spent summers in large villages practicing agriculture, while in the winter they separated into family units and hunted.

The Sauk, Fox and Menomini occupied the area adjacent to the western shore of Green Bay through the eastern portion of the Upper Peninsula. The Sauk and Fox occupied permanent villages during the summer, during which their subsistence was based on cultivation of corn, beans, and squash and the gathering of wild rice. During the winter the entire tribe moved west to the prairies and prairie transitional zones to hunt buffalo. The Menomini, on the other hand, were much more tied to collecting and agricultural pursuits. The Menomini subsistence appears to have primarily been dependent upon the harvesting of wild rice, more so than any other group in the basin. Living in sedentary villages, fishing represented an

important economic activity for the Menomini, while hunting was relatively less important.

The Winnebago represent the sole extension of the Sioux speaking family into the Great Lakes Basin. Regardless, archaeological evidence indicates that the Winnebago had occupied much of the west shore of Lake Michigan for hundreds of years before the advent of European contact, and their culture was similar to that of the Sauk and Fox. They lived in permanent villages from which they engaged in agricultural pursuits during the summer. After the fall harvest the group journeyed to the southwest to hunt buffalo.

Occupying the area abutting on essentially the southern third of Lake Michigan, the Miami group was also very similar in culture to the Sauk and Fox. Like these groups, the Miami lived in permanent villages. They practiced agriculture in the summer and moved to the prairies to hunt buffalo during the winter.

The Huron inhabited much of the area west of Lake Huron and north of Lakes Erie and Ontario. The Hurons were perhaps the most sedentary of the groups within the Great Lakes Basin. Dwelling in towns and villages, one of the largest of which had a population of between 4000 and 6000 inhabitants, the Hurons were primarily agriculturalists. It is estimated that the Huron had over 23,000 acres of corn under cultivation. Hunting and fishing are considered to have represented 25 percent or less of annual food consumption, and fishing was much more important than hunting.

Various Iroquois groups, including the Seneca, Cayuga, Onondaga, Oneida, and Mohawk, inhabited the area south of Lake Ontario. Together these groups formed the Iroquois Confederacy, an organization whose force was felt as far west as the Mississippi River. Like the Huron, these peoples were primarily agriculturalists, with elaborate ceremonies structured around the maize cycle.

Excluding possible earlier Norse ventures, initial European penetration into what was to become the Great Lakes-St. Lawrence Seaway system is believed to have been a journey of eighty leagues up the St. Lawrence River by the French explorer Thomas Aubert between the years 1534 and 1541. While he did not succeed in gaining the lower lakes, his contacts with the Indians in the area brought knowledge of the existence of Lakes Ontario, Erie, and Georgian Bay of Lake Huron.

European "discovery" of the lakes themselves began with the discovery of Huron by LaCaron and Champlain in 1615, and Champlain went on to find Lake Ontario in the same year. Lake Superior became kngwn about 1629 through the efforts of Etienne Brule, with the discovery of Lake Michigan by Jean Nicolet coming five years later. The late discovery of Lake Erie in 1669, probably by Joliet, is attributable to its presence in the center of the hostile Iroquois Confederacy.

French missionaries provided the primary continuous contact in the region during the mid-15th century. Missions established on Georgian Bay early in the century provided the staging area from which missionary influence spread into the other upper lakes. Their efforts were thwarted largely by the Iroquois Confederacy through its destruction of the Huron tribe, which had provided the base of support for the missions.

The primary commercial use of the Great Lakes for a century and a half after their discovery was as a route for fur traders. Montreal was an earlier center, but as beaver, mink and otter stocks became depleted and the demand for furs in Europe continued unabated, the French voyageurs extended their routes farther to the west. In search of furs, these men were the first Europeans of venture into much of the continent.

The British founding of the Hudson Bay Company and its subsequent initial operations on Hudson Bay led the French to fear for their monopoly on the lakes. Reinforced by intriguing reports of the copper available in the Lake Superior region, the French in 1671 claimed possession of the lakes and their basins. As a means of restricting the access of British

traders to the lakes, the French established forts at various strategic locations on the lakes, including Saulte Ste. Marie and Mackinaw. The various ploys and counterploys of the British and their allies of the Iroquois Confederacy and of the French and their Indian allies which led ultimately to the seven year's war (1756-63), in which the British gained control over the Great Lakes.

The competition between rival fur companies that followed British control led to the building of a few relatively large ships for fur transport. These represent the first commercial shipping of a significant scale on the lakes (see separate section on shipping history).

The fur trade had a catastrophic effect on the Indians in the basin. As they came to desire the trade goods Europeans offered, their native economic systems suffered, thus bringing greater dependency upon the fur trade. As a result, cultural dissimilarities between Indian groups tended to be damped patterns oriented toward hunting and trapping. The influences of European material culture, including liquor, thus served to help create what has been termed a Ran-Indian culture that lasted from prior to 1760 to about 1820. When stocks of fur-bearing animals became depleted, forcing the fur traders to move west, the economic dependency of the Indians was such that they were left without a livelihood. Faced with the encroachment of white settlers, their culture fragmented and was largely lost.

After the Revolutionary War, the Treaty of Paris established the international boundary through the middle of the St. Lawrence River, Lake Ontario, Lake Erie, Lake Huron and through Lake Superior north of Isle Royale. The British retained their post on the southern shores of the upper lake, which they surrendered after Jay's Treaty in 1796.

With the securing of the boundary as a result of the War of 1812 and increased levels of immigration into the United States from Europe, the character of the Great Lakes basin began to change. Farmers originally from Central Europe and Scandanavia cleared most of the southern portion of

the basin, establishing a strong agricultural base. As this base developed, its demands were met by the growth of a lumber industry to the north. Exploitation of the mineral resources of the region also grew, with the first shipments of copper from Copper Harbor in the Keewenaw Peninsula sent to Massachusetts in 1845.

The openings of the Erie Canal in 1825, the Welland Canal in 1829, and the opening of the locks at Sault Ste. Marie in the 1850's facilitated the development of industrial complexes utilizing the various resources of the basin. The steel industry of the basin is perhaps the best example of this process. The opening of the St. Lawrence Seaway, providing a route to the Atlantic Ocean for large vessels, secured the position of the Great Lakes basin as an individual center of international importance.

A Brief History of Shipping on the Great Lakes

Shipping on the Great Lakes began in 1679 when LaSalle's vessel, the Griffin, embarked and was lost on its maiden voyage. By the mid-1700's various British sailing ships had begun operations on Lake Erie, American ships were on Lake Ontario. These vessels were wooden, sail-powered schooners or brigs.

Around 1815-1818, steam powered vessels were initiated. Most of the early "Steamers" were wooden and still used sails. Most vessels were underpowered. Typical cargos consisted of dry cargo, miscellaneous goods and passengers.

By the 1820's population densities around the Lakes were increasing and demand for goods and production of exportable products further stimulated monetary incentive for shipping. With the completion of the Erie Canal in 1825 and the Welland Canal in 1829 the advent of extensive Great Lakes Navigation began. Typical cargos consisted of grains and dry goods. During the 1830's the main vessels were sail-powered or steam powered. Steamers were using less wood and more coal for fuel until they used coal exclusively by the 1850's.

In 1840 the screw-type propeller was introduced and proved more efficient and convenient in harbor navigation than the side wheel paddle wheels.

The first light houses were erected on Lake Erie in 1818 and slightly earlier on Lake Ontario. By the 1830's-40's there were some channel and shoal markers on the open lakes but navigation relied primarily on the ship master's knowledge of the lakes. The Rivers and Harbors Convention of 1847 (and later in 1887) met and established a system of markers and buoys for channels and harbors. Before this convention the navigational aids consisted only of markers maintained by the individual ports. In the late 1840's the Government began the U.S. Lake Surveys and the first chart was mapped in 1853.

After the opening of the Sault Canal in 1855 lumber, coal, and ores became important cargos. These heavy bulk cargos initiated a continual development of larger and heavier powered ships, as well as deeper channels and dredging in harbors. By the 1890's huge barges and freighters were supplanting the old smaller sailing vessels.

Increasingly heavy traffic, heavier cargos, larger ships, frequent storms and inexperienced foreign pilots all contributed to shipping accidents. Collisions, fires, floundering and running aground were common during the late 1800's- early 1900's period. Better maps, experience and improved navigation aids such as fixed radio direction finders (beacons) in the 1930's, radar in the 1950's, more precise weather reporting and more powerful oil and petroleum fueled engines all helped to prevent shipwrecks and enabled safer navigation.

Recent innovations such as pinpoint weather reporting from ship reports and recon buoys with elaborate weather and water condition detection devices have also improved navigation. More numerous fixed navigation

beacons and a program called LORAN-C, an open-water position-fix device, have helped to control the huge modern ships sometimes as large as 1000' x 105' size.

The heavy shipping traffic, the shallow waters, foreign ships with pilots unfamiliar with the lakes, the unpredictable severe weather patterns, and the simple lack of room on the lakes to run from or evade storms, all make the Great Lakes more treacherous for shipping than the open oceans. In spite of all the navigation aid improvements in 300 years of shipping, shipwrecks continue to occur and the lake bottoms are littered with over 6000 wrecks. Each wreck is a segment of Great Lakes shipping history.

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Methods and Results

The state by state survey of records and literature for cultural resources potentially impacted by winter navigation practices was based upon a number of assumptions and constraints. A review of the potential impacts are presented below.

The constraints used included the following:

1. The search for site locational data was restricted to areas within 500 feet of the shoreline.

2. The shoreline areas covered by the search were restricted to the 43 studied harbors, (including additional possible ice breaker ports as well as commercial harbors) channels, and connecting waterways.

3. Areas adjacent to harbors were included in the search if it appeared that vessels might pass within two miles of the shore while entering or leaving the harbors.

4. Historic lighthouses were generally included if they were on a shipping lane likely to be used in the winter. The assumption was that these would generally be within an unspecified closeness to the shipping lane or they would not have been built.

5. Areas such as the northern tip of the Keewenaw Peninsula and various capes were included on the assumption that shipping might pass close enough to provide some negative impact.

6. Coastlines of broad areas of open expanses of water were not checked. The coastline between Duluth and Two Harbors was not examined since ships passing between those ports in the winter would remain more than two mile offshore and not be likely to impact shore cultural resources or submerged resources.

The specific sources used in this study are detailed in the preliminary comments on each state. A bibliography accompanies each state section.

Though a considerable amount of time and energy has been expended in the continuing study of the Navigation Season Extension Survey, a firm grasp of the direct physical impacts of the season extension upon the curtural resources located on the shoreline and harbors of the Great Lakes System is still elusive. Although some studies of the problem have been initiated (Wuebben, Gatto and DenHartog, 1978) the results so far are incomplete; furthermore, these studies deal mostly with the connecting channels. Because of the lack of data regarding both natural phenomena and ship induced impacts on the shoreline, it is necessary to briefly list potential adverse effects of the season extension with an estimate of the types of cultural resources most likely affected.

Cultural resources, for the purposes of this report, consist of known prehistoric archaeological sites, archaeological sites associated with the historic (European) period, extant historic structures and submerged ship wrecks. The arbitrary 500 foot limit from the shoreline selected as the study limit can be considered to provide an excessive margin of safety. In fact, any cultural resources located more than 100 feet from the shore would probably not be affected by the activity caused by the season extension except in cases of construction of facilities.

With the exception of those impacts directly caused by winter ice action itself, indirect adverse impacts of maintaining winter navigation passages could be caused by exposure of the shoreline and harbors to increased hydrological movements, propeller wash, wave wash from vessel passage and mechanical vibrations for the entire year instead of the normal eight months. Additionally, channel dredging and related construction of navigation devices, ice stabilization structures and shoreline protection factilities could all impact on cultural resources if present. Following is a brief list of possible damage producing agents and estimated effects on cultural resources. Hazards from oil spills might aesthetically impact harbor structures, but in general oil or other inorganic chemicals are probably not substantial impacts to cultural resources.

Ice: Ice cover on those ports which normally freeze over in the winter provides a degree of protection from the adverse effects of severe hydrological movements and ship-induced effects by dampening the severity of water movement. Ice breaking or clearing activity reverses the dampening effect and allows the moveable ice chunks to scour or gouge the shore and nearby shallows during times of vessel passage or winter storms. One well documented case of natural ice scour affecting an archaeological site exists in Ohio.

> "During the spring of 1978, the breakup of ice cover on the Maumee River led to major flood and ice scour erosion in portions of the lower Maumee Valley...at the MacNichol site, area ice scour resulted in the removal of plowzone or topsoil from four to five acres, at least half of which consisted of portions of the site, exposing upwards of one hundred archaeological features. Since

the site is characterized by numerous deep pits, complete destruction of features occurred only when, as along the eastern edge of the site, erosion was carried to over two meters in depth..." (Pratt, n.d.)

Only those cultural resources, i.e., archaeological sites and historical structures located directly adjacent to the shore either in harbors or close to shipping lanes are likely to be impacted by ice movement itself. Likewise, shipwrecks within shallow water or near shore could be severely damaged by ice movements.

Hydrological movements/Wave wash: The natural movements of water due to wind or ship-induced bow waves and troughs, depending on the severity of movement, could contribute to shoreline erosion. Erosion of unprotected shorelines could affect archaeological sites and possibly historic structures contiguous with the shore.

Mechanical vibration: Operating speeds within harbors in near shore areas would be slower than in open waters and since low speed, high powered ice breakers would be at work in these harbors some mechanical vibrations can be expected. While the effect of such vibration may be minimal on archaeological sites there could be a potential hazard of long term cumulative effect on the integrity of nearshore historic structures.

Propeller wash: This ship-induced effect is only localized and could potentially affect shipwrecks within range in less than 50 feet of water.

Channel Dredging and Construction of Navigation Aids: Both archaeological sites and historic structures located on points of land near shipping channels or harbor mouths would be identified in

early planning and design stages of the program and any potential adverse effects would be eliminated. If sites were identified after construction was underway, the project would be halted pending evaluation of the findings at this point, further action would be coordinated with the State Historic Preservation Officer and any others as required.

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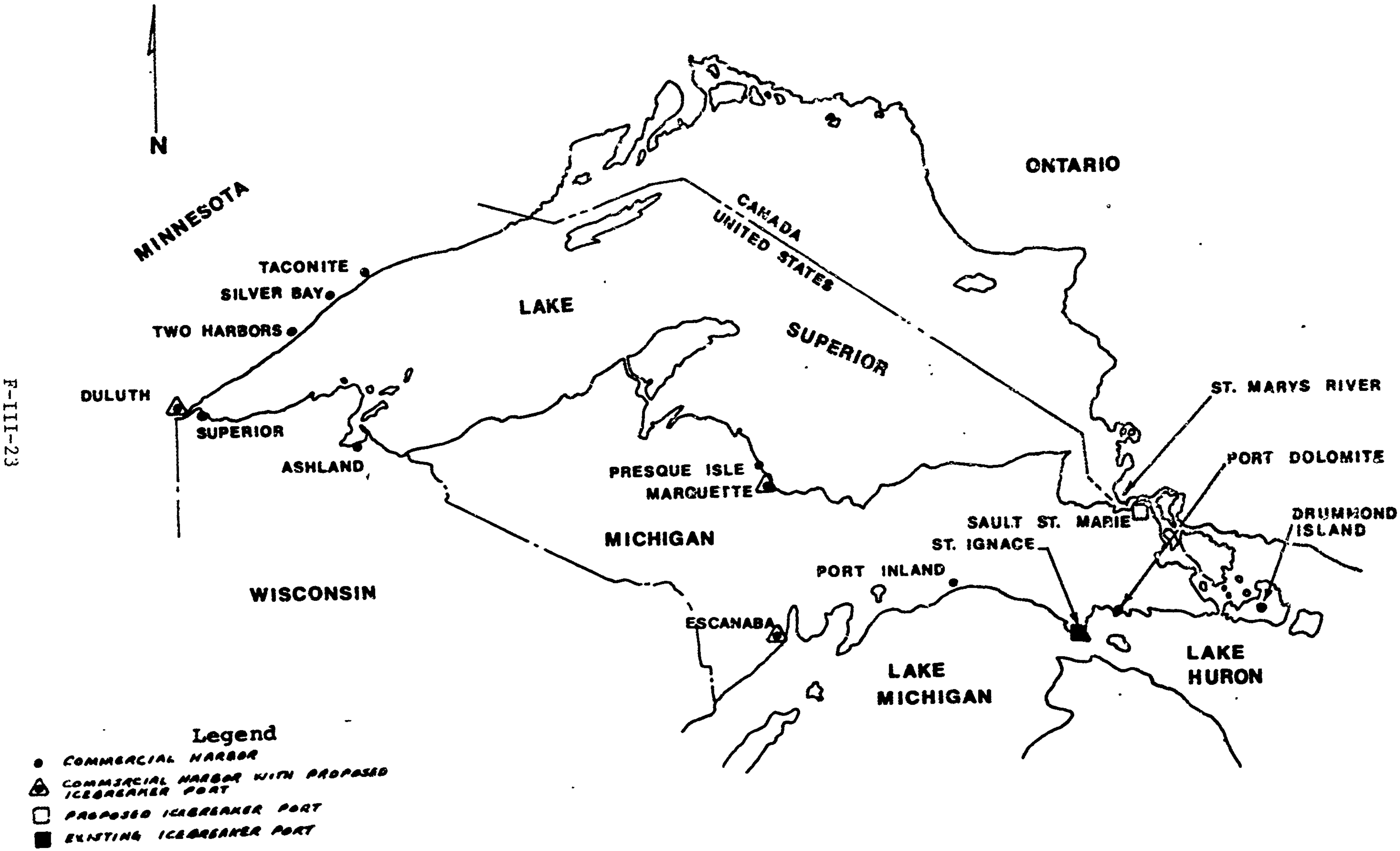
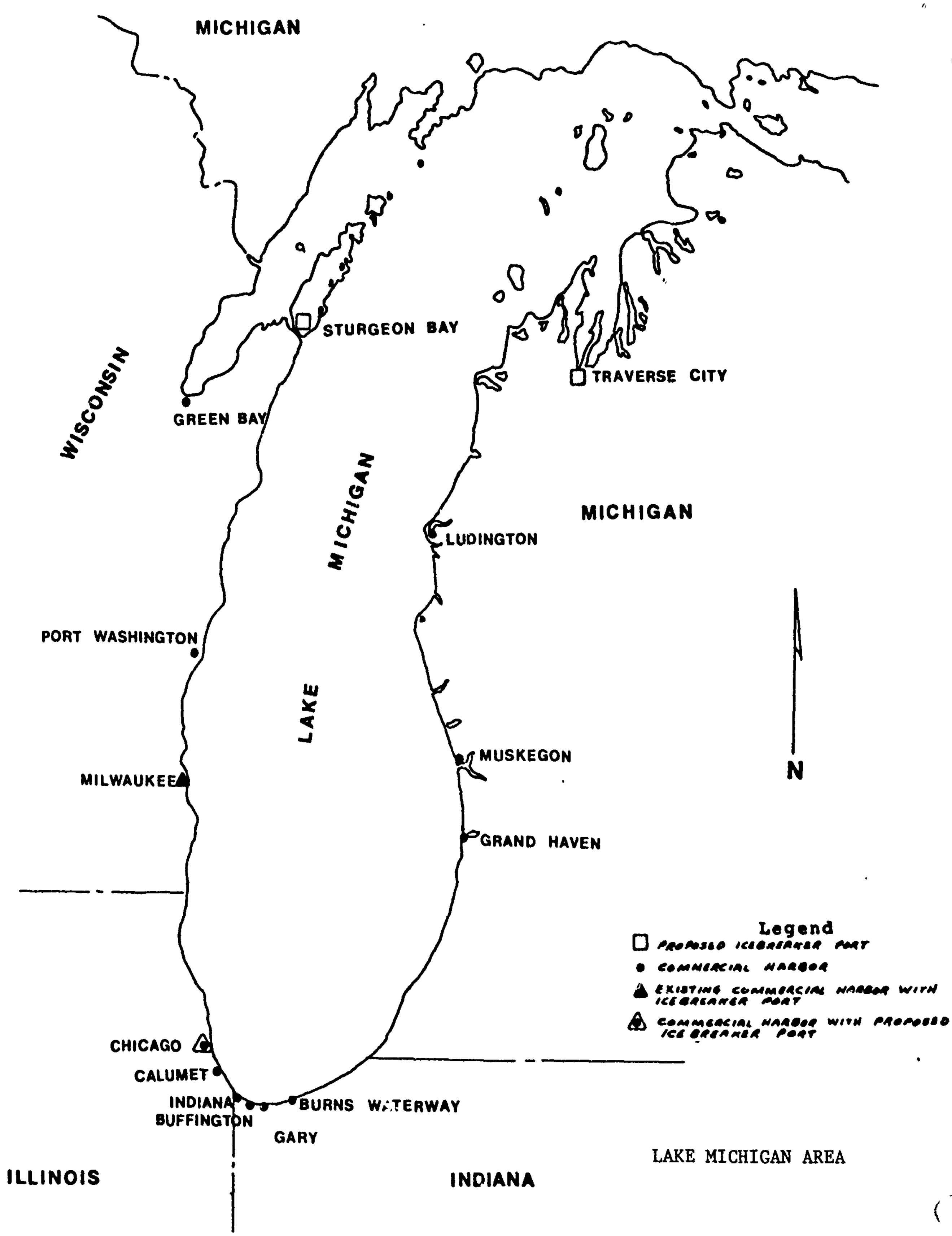
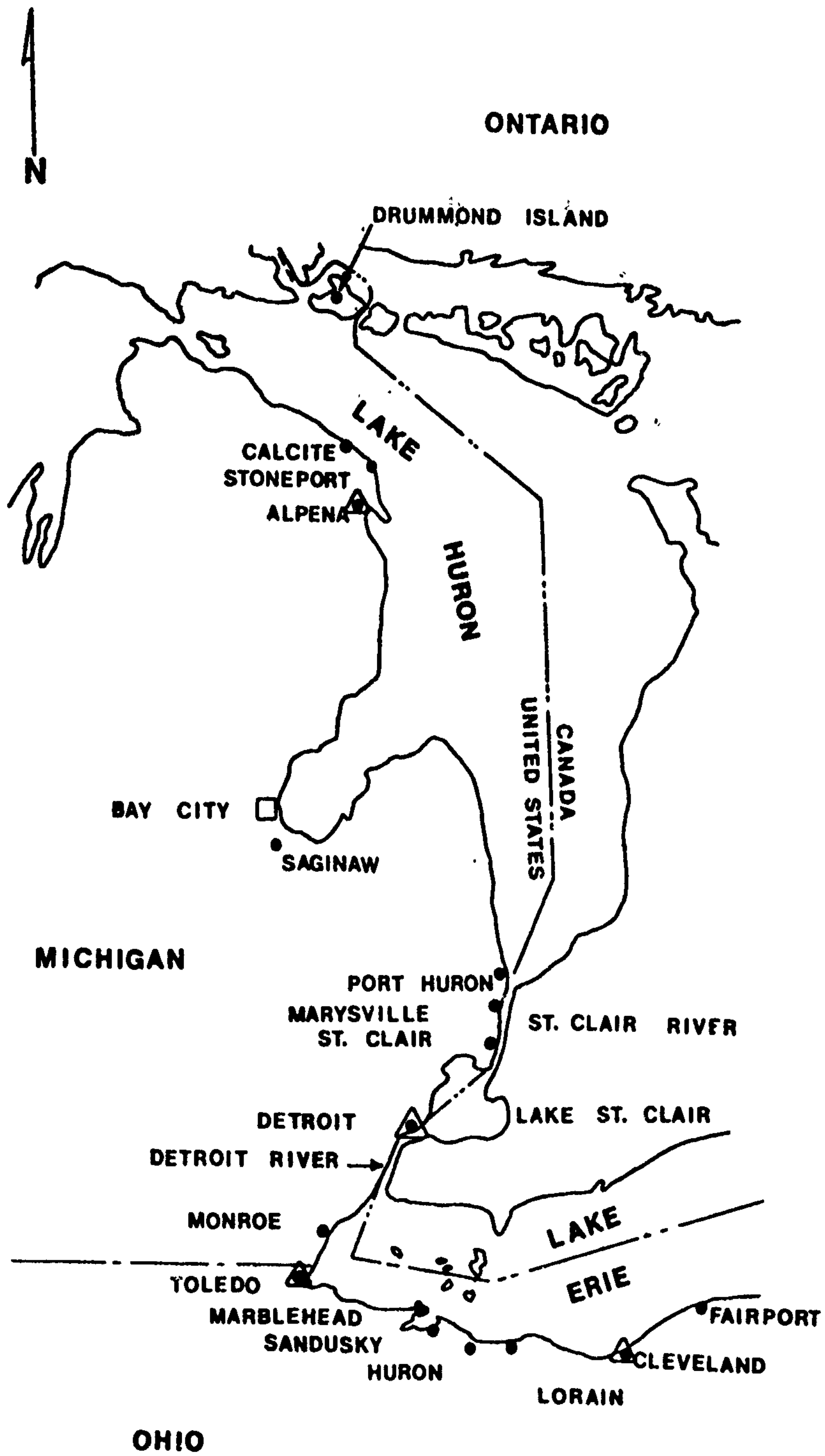


LAKE SUPERIOR AREA



LAKE MICHIGAN AREA



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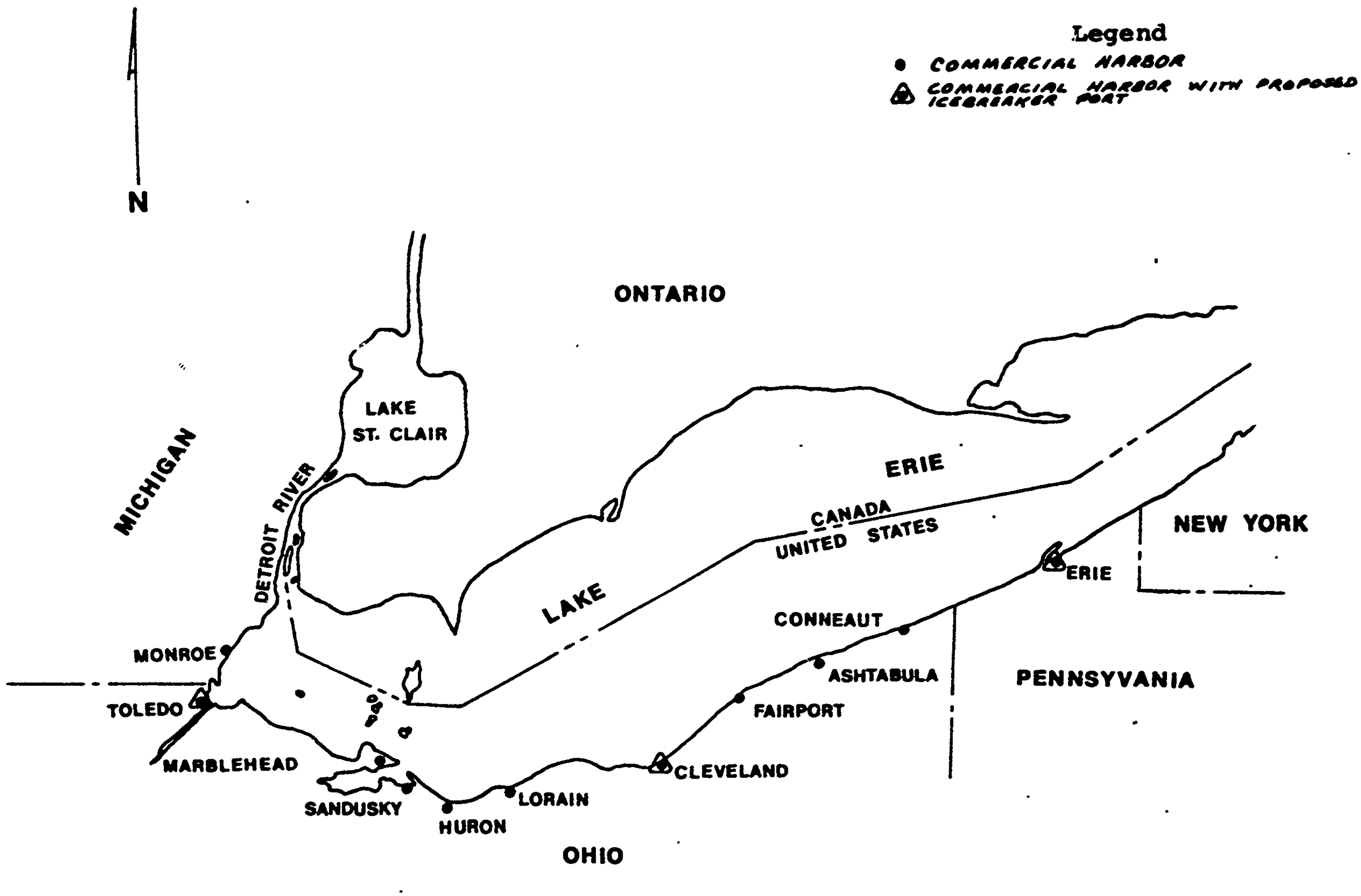
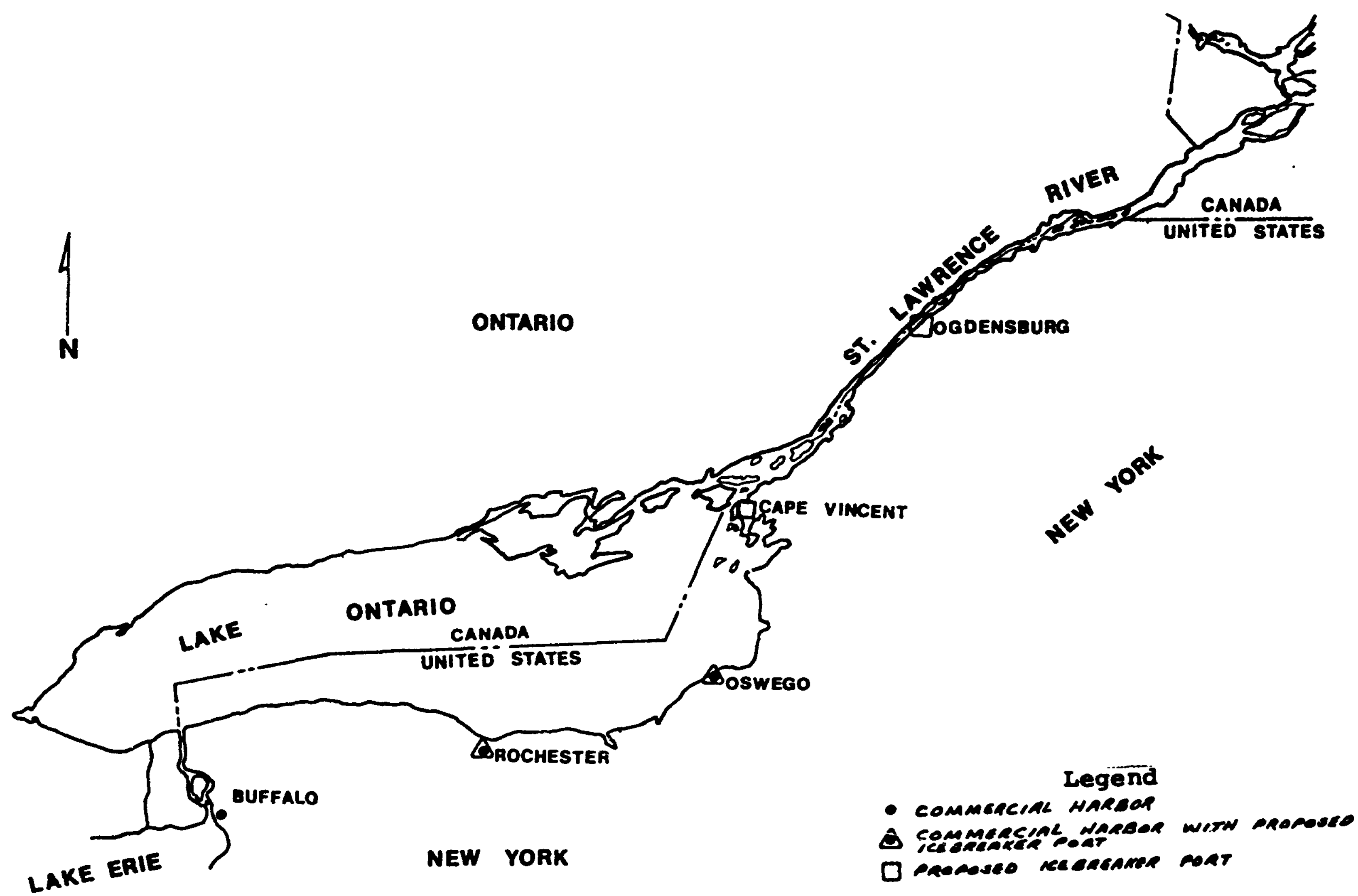
- • COMMERCIAL HARBOR
- ▲ COMMERCIAL HARBOR WITH PROPOSED ICEBREAKER PORT

LAKE HURON, LAKE ST. CLAIR AREA



LAKE ERIE AREA



LAKE ONTARIO AND THE INTERNATIONAL PORTION OF
THE ST. LAWRENCE RIVER

Minnesota

The main repository for cultural resource information in Minnesota is the Minnesota Historical Society staff office at the James J. Hill House in St. Paul. The Hill structure houses updated Minnesota archaeological and historical site files by county in addition to serving as office quarters for Historical Society architectural historians and a segment of the archaeology staff. The Hill House preservation staff also includes a legal counsel and an environmental assessment officer.

Along the north shore of Lake Superior, four harbors comprise the project areas investigated. They include Duluth-Superior Harbor (St. Louis Co.), Two Harbors (Lake Co.), Silver Bay (near Beaver Bay in Lake Co.), and Taconite Harbor (Cook Co.). The county historic site files for the three pertinent counties were scanned in detail for historic structures, sites, cemeteries objects, shipwrecks, etc., which are located within the harbor areas. Project boundaries extend 500 feet inland from the harbors and one mile to each side of the shipping lanes. Known archaeological sites which are also filed by county and marked on a U.S. Department of Transportation Minnesota county map book were also checked. In Minnesota archaeological files, great variability exists in the number of surveys conducted for each county. A few counties in the central portion of the state have been extensively surveyed. However, the counties that border Lake Superior have not been surveyed systematically to date. In addition to historical and archaeological data, the Historical Society's site files were scanned for paleontological sites within the four harbor areas. No such sites have been discovered to date in the project areas.

In 1976 an exhaustive cultural resource study of the Duluth-Superior Harbor area was conducted by the Minnesota Historical Society through a contract under the St. Paul District of the U. S. Army Corps of Engineers. Approximately 330 historic locations

which include bridges, portages, piers, buildings, mills, trading posts, historic Indian sites, etc. were located by the study. Of the 330 historic sites, over 80 are extant with variable degrees of degradation. The study concludes that 18 sites, all in Duluth, may be considered major cultural resources. Currently, six sites within the harbor area are listed in the National Register of Historic Places. The harbor report mentions that at least four other sites within the area are potentially eligible for the National Register (Walker 1976:112). In addition to the pertinent historic sites mentioned in the Duluth-Superior study, several historic structures within 500 feet of the harbor area were included in the 1976 edition of the Minnesota Inventory of Historic Places. The major question for the Duluth-Superior harbor area remains the extent and significance of the old Duluth Harbor ruins which lie to the east of Third Avenue in 30 feet of water (Engman 1974:8). The intensive development and utilization of the Duluth-Superior Harbor area over the last century serves to explain the paucity of the archaeological data base.

The historical and archaeological data base for both Lake and Cook Counties, Minnesota, is quite scarce. Due to the inaccessibility of large portions of these counties and the sparseness of the population, very few site surveys have been commissioned. Although the Minnesota Historical Society is planning future surveys of this eastern region, currently only a few sites have been recorded for Lake and Cook Counties.

Two Harbors is an area which has been inventoried adequately by the Lake County Historical Society in terms of Historic structures. The Minnesota Historical Society is developing the idea of creating a Two Harbors Historic District. No archaeological resources have been identified at Two Harbors to date by the Minnesota Historical

Society's archaeological staff.

Silver Bay, and adjacent Beaver Bay, also reflect the same lack of documentation. A shipwreck and an iron ore plant are the only two historic sites inventoried for Silver Bay. Beaver Bay contains two possible historic Indian sites at the southern edge of its small harbor. The Chippewa Indian cemetery has as yet, not been evaluated by the Minnesota Historical Society preservation staff. Fritzen (1975:14) published a painting from 1870 which locates three Indian tipis at the south rim of the harbor.

Little is documented of the history surrounding the Taconite Harbor area. The only comment uncovered pertaining to the history and archaeology of the area involves the sinking of the Barge George Herbert within the harbor area in 1905 (Hudak 1976:25). No exact site location is provided.

The Minnesota Historical Society has indicated that the Steamer Hesper wreck in Silver Bay represents a significant historical resource that should be protected from harbor disturbance activities. In general the extended winter navigation system would probably not impact historical and archaeological resources in Lake Superior harbors. Docks, structures, and historic ships which could be impacted are already surrounded by high vibration levels and ice shifting during the course of a normal year's harbor activities.

MINNESOTA CULTURAL RESOURCES

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
	Possible Historic Indian campsite on S.W. shore	Beaver Bay	none	unknown	From 1870 painting of Beaver Bay (Fritzen 1974: 14)
	Historic Chippewa cemetery c.1865	Beaver Bay	Minnesota Historical Society site files	unknown	Undetermined significance
	Taconite Plant of the Reserve Mining Company	Silver Bay	Minnesota Historical Society site Files	minimal	Significance of structure questionable. Built in 1955
	Three Spot Locomotive and Cars S.W. corner of 1st Av. and Main	Two Harbors	Minnesota Inventory of Historic Places, 1976	minimal	First locomotive used on the Duluth and Iron Range Railroad, 1883
	Two Harbors Lighthouse So. end of 3rd St.	Two Harbors	Minnesota Inventory of Historic Places	possible vibrational effects from icebreaking	Built in 1892. One of two remaining lighthouses in Minnesota. The only other is split Rock Lighthouse, 38 mi. N.E. of Duluth
#44	Indian Village 1850's. Indian and white cemetery 1860's	Duluth--Superior Harbor	none	unknown, unexcavated sites	Harbor map Walker 1976
#17	Indian Portage 1679, in Government Park	Duluth--Superior Harbor	none	minimal	Harbor map Walker 1976
#23	Aerial Lift Bridge, Lake Av. at the canal	Duluth--Superior Harbor	On the National Register and Minnesota State Register	minimal	Harbor map Walker 1976
	Bergetta Moe Bakery, 716 E. Superior St.	Duluth--Superior Harbor	On the National Register and Minnesota Inventory of Historic Places	minimal	Also known as October House, within 600' of Harbor

Minnesota:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
	Chester Congden House, 3300 London Rd.	Duluth--Superior Harbor	Minnesota Inventory of Historic Places	minimal	Jacobean Architecture, within 500' of Harbor
	Crooks Train Engine, 506 W. Michigan St.	Duluth--Superior Harbor	Minnesota Inventory of Historic Places	minimal	Located at the Depot Railroad Museum
	Duluth Union Depot	Duluth--Superior Harbor	On the National Register and Minnesota State Register	minimal	Chateauesque style architecture within 1000' of Harbor
	Endion Passenger Depot, 1504 South St.	Duluth--Superior Harbor	On the National Register and Minnesota Inventory of Historic Places	minimal	Romanesque style within 500' of Harbor
	Fitger's Brewery, 600 E. Superior St.	Duluth--Superior Harbor	Minnesota Inventory of Historic Places	minimal	within 1000' of Harbor
	Hartley Office Building, 740 E. Superior St	Duluth--Superior Harbor	Minnesota Inventory of Historic Places	minimal	within 100' of Harbor
	Kitchi-Gammi Club, 831 E. Superior St.	Duluth--Superior Harbor	Minnesota Inventory of Historic Places	minimal	Fraternal Social Institution within 1000' of Harbor
	Police Station and Jail, 126 E. Superior St	Duluth--Superior Harbor	Minnesota Inventory of Historic Places	minimal	Romanesque style within 1000' of Harbor
#19	Duluth Ship Canal c.1871	Duluth--Superior Harbor	Potentially Eligible for National Register	Icebreaking could affect canal walls	Harbor map Walker 1976

Minnesota:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
#48	U.S. Topographical Engineers original survey and baseline c.1861	Duluth--Superior Harbor	Potentially eligible for National Register	minimal	Harbor map Walker 1976
#48	First Lighthouse, Minnesota Point c.1858	Duluth--Superior Harbor	On the National Register	minimal, possible vibrational impact	Harbor map Walker 1976
#204	McDougall--American Steel Barge Company c.1889	Duluth--Superior Harbor	Potentially eligible for National Register	minimal, ice shifting may affect the dock	Harbor map Walker 1976
#166	Duluth, Missale and Iron Range Railroad Ore Docks, c.1914	Duluth--Superior Harbor	Potentially eligible for National Register	minimal, ice shifting could damage dock face	Harbor map Walker 1976
#121	The Northern Pacific Railway Drawbridge	Duluth--Superior Harbor	none	minimal, ice shifting could damage bridge supports	Built in 1885, Harbor map Walker 1976
	The Old Duluth Harbor	Duluth--Superior Harbor	none	icebreaking could damage submerged dock ruins and cribs	First used August 26, 1871. In 30' of water. (Engman 1974:8)

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Wisconsin

The central repository for site records and files concerning cultural resources is at the Wisconsin Historical Society located on the campus of the University of Wisconsin, Madison. The Historical Society houses, not only the extensive historic archieves of the State of Wisconsin, but includes in addition to a large museum, curational facilities for historic and prehistoric artifactual material. The Historical Society also contains the staff offices of the Historic Preservation Division of the State of Wisconsin.

The project areas investigated totaled five harbors, two on the south shore of Lake Superior and three on the western shore of Lake Michigan. They include Duluth-Superior Harbor (Douglas Co.) and Ashland Harbor (Ashland Co.) on Lake Superior, and Green Bay Harbor (Brown Co.), Port Washington Harbor (Ozaukee Co.) and Milwaukee Harbor (Milwaukee Co.) on Lake Michigan. The county files and maps for these five counties were cross indexed and searched for known prehistoric archaeological sites, historic archaeological sites, extant structures of historic significance or shipwrecks which might comprise an inventory of cultural resources within the project areas. Project boundaries were arbitarily set 500 feet inland from the harbor shoreline and one mile on each side of the shipping lanes approaching the individual harbors.

All archaeological sites recorded within the five harbors are known only from general references in early historical accounts. The exact locations of the sites remain extremely imprecise and unverified. Over a century of urbanization has obliterated most, if not all surface indications of these sites and subsurface integrity must, for the same reasons remain doubtful. No on-site archaeological investigation of these sites has been conducted in any of these areas. Systematic collection of data pertaining to

historic structures has only been initiated since passage of the Environmental Acts of the late 60's and only three of the five harbors (Port Washington, Green Bay and Milwaukee Harbors) have had systematic surveys for historic structures. Data from the most recent survey, that of Milwaukee Harbor, had not yet been processed and were unavailable for study, although numerous historic structures apparently have been identified.

The historic structure survey of Green Bay Harbor lists fourteen potentially significant structures but these were confined to the Green Bay city limits and did not extend upstream on the Fox River to De Pere, the maximum extent of the Navigation Season Extension Program boundary. Port Washington Harbor seemed to be the most adequately studied, in terms of the needs of the present project. A total of twenty-six potentially significant structures were noted within the 500 foot limit of the study. Systematic historic structures surveys conducted to date are at a preliminary stage and an evaluation of potential significance would be made after further studies as required.

The 1976 cultural resource study of the Duluth-Superior harbor area (St. Paul District of the U.S. Army Corp of Engineers) lists approximately fifty-two historic sites or structures in Superior Harbor within the 500 foot limit. The Wisconsin Historical Society records list only eight possible historically significant structures in the same area. Additional work may be required in Superior Harbor.

The remaining study area, Ashland Harbor, has not been the object of any systematic historic structure survey although numerous potentially significant structures do exist.

The records housed at the Wisconsin Historical Society listed no known shipwrecks within the harbors. Although numerous divers guides

and shipwrecks inventories exist, none gave adequate enough locations to place wrecks within the study limits. The existance of any paleontological resources within the study areas was unknown.

WISCONSIN

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
47 Mi 56	Oval Mounds possible effigy Mound. Affiliation unknown	Milwaukee Harbor	Not on the National Register	unknown	Site recorded from literature. Obliterated by Railroad yards.
47Mi82	Conical burial mound. Affiliation unknown	Milwaukee Harbor near State Road bridge	Not on the National Register	unknown	Site recorded from literature
47Mi86	Indian Cemetery. Affiliation unknown	Milwaukee Harbor near Walkers Point.	Not on the National Register	unknown	Known from literature Site obliterated by grading 1838
47Mi98	Cornhills-visible in 1833	Milwaukee Harbor	Not on the National Register	unknown	Site recorded from literature
47Mi107	"Enclosure" (Earthworks?)	Milwaukee Harbor	Not on the National Register	unknown	Location and references very sketchy
	Gimbels	101 W. Wisconsin Ave.	Nominated		Historic structure on or near the Milwaukee River
	Iron Block	205 E. Wisconsin Ave.	On the National Register		Historic structure on or near the Milwaukee River
	Mackie Building	225 E. Michigan Street	On the National Register		Historic structure on or near the Milwaukee River
	Milwaukee City Hall	200 E. Wells Street	On the National Register		Historic structure on or near the Milwaukee River
	Mitchell Building	207 E. Michigan Street	On the National Register		Historic structure on or near the Milwaukee River
	Pabst Theater	144 E. Wells Street	On the National Register		Historic structure on or near the Milwaukee River
	Plankinton Arcade	161 W. Wisconsin Avenue	Nominated		Historic structure on or near the Milwaukee River
	Walkers Point Historic District	Roughly bounded by the freeway, Monomonee Canal, Scott, 2nd, and W.Va. Streets	On the National Register		Not sure of exact location but may be in the study area
47Dg06	Prehistoric campsite. Affiliation unknown	Superior Harbor at base of Conners Point	Not on the National Register		Reported from literature search, location not precise
47Dg09	Burials Affiliation unknown	Superior Harat base of Conners Point	Not on the National Register		Reported from literature search, location not precise

Wisconsin:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
47Dg24	Village and Cemetery (Chippewa)	Superior Harbor at Wisconsin Point	Not on the National Register	unknown	Reported from literature search location not precise
47Dg25	Village Affiliation unknown	Superior Harbor Clough Island (St.Louis River)	Not on the National Register	unknown	Reported from literature search location not precise
"Meteor"	Whaleback carrier	Superior Harbor Barkers Island NW tip	On the National Register	potential impact	Placed on Register 9-9-74
47As55	Village, unknown affiliation	Ashland Harbor	Not on the National Register	unknown	Unverified site location from literature search
47Br2	Village site, unknown affiliation	Upriver of Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br9	Cache of Artifacts	Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br12	Burials	Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br15	Village, Affiliation unknown	Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br18	Oval Mound Affiliation unknown	Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br89	Village, Affiliation unknown	Upriver from Green Bay	Not on the National Register	unknown	Site known from literature. Destroyed
47Br90	Campsite, Affiliation unknown	Upriver from Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br94	Village, Affiliation unknown	Upriver from Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br135	Village (Sauk?)	Upriver from Green Bay	Not on the National Register	unknown	Unverified location known from literature
47Br136	Village and Cemetery Menominee	Green Bay	Not on the National Register	unknown	Precise location unverified
47Br137	Village, Affiliation unknown	Green Bay	Not on the National Register	unknown	Known from literature
47Oz9	Village site Potawatomi(?)	Port Washington	Not on the National Register	unknown	Location Imprecise Known from literature

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Illinois

The main repository for cultural resource information in Illinois is the Illinois Department of Natural Resources (DNR). The department's prehistoric site archaeologist was consulted for information on known sites in the two Illinois harbor project areas, Chicago Harbor and Calumet Harbor. A memorandum to the Director of the Illinois State Clearinghouse stated that there were no known sites either in the Chicago or Calumet Harbors. Chicago Harbor is built entirely upon fill and would not contain any in situ archaeological sites. The Illinois DNR did indicate that there was a remote possibility that a small segment of land had not been disturbed in Calumet Harbor, but that it was considered, the possibility did not warrant an archaeological survey.

An extensive structures survey has been conducted for the Chicago coastline. Those sites within the 500 foot limit are inventoried on the following page.

ILLINOIS

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
	Chicago Harbor Lifeboat Station	Chicago Harbor	National Register pending	possible impact	Projected to be used as base for the Lakes and Marine Historical Museum
	Navy Pier	Chicago Harbor	City Historical Site	possible impact	
	Naval Armory	Chicago Harbor	Determined architecturally significant by city of Chicago	possible impact	Evaluated by Commission of Chicago Historical and Architectual Landmarks
	Bridge House and Light standards	Chicago Harbor	Determined architecturally significant by city of Chicago	possible impact	Evaluated by Commission of Chicago Historical and Architectual Landmarks
	Chicago River Rocks	Chicago Harbor	Determined architectually significant by city of Chicago	possible impact	Evaluated by Commission of Chicago Historical and Architectual Landmark
S.S. 236	U.S.S. Silversides, W.W. II submarine 1941	Chicago Harbor	On the National Register	unknown	Will be docked at Chicago Harbor Lifeboat Station
AVR 661	R-1 type Airforce Crash Boat, 1943	Calumet Harbor	On the National Register	None unless docked in Harbor	Reconstructed and protected

Indiana

A primary contact for cultural resource information in Indiana is the Division of Historic Preservation in Indianapolis. The State Historic Preservation Officer's (SHPO) Historian listed information concerning historic structures in each county in the project area. The SHPO archaeologist was helpful in providing information on prehistoric cultural resources.

The site files at the Indiana University Glenn A. Black Laboratory of Archaeology were researched for any potentially impacted archaeological sites in the harbor areas.

Along the Lake Michigan shore of Indiana, four harbors comprise the project areas investigated. These harbors include Indiana, Gary, and Buffington Harbors in Lake County; and Burns Waterway Harbor in Porter County. The County site files were referenced for both prehistoric and historic sites in each of the harbor impact areas.

Record checks and literature searches in the concerned counties indicate that no cultural resources have been recorded for either Porter or Lake Counties.

Two sites were recorded in the Glenn A. Black Laboratory files for the Little Calumet River area, both outside of the present project impact area.

A 1968 National Park Service Report indicated 12 sites in the Indiana Dunes National Lakeshore area. Four of these sites are in the project impact area and are recorded in the Glenn A. Black Laboratory site files.

Unfortunately there is a paucity of data on archaeological and historical resources in Porter and Lake Counties. An inventory of the sites in the project impact area and vicinity follows.

INDIANA

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
12 Pr 1	Human Skeletal material & projectile point from "blowouts" possible prehistoric cemetery	ca.4½ miles east of Burnes Waterway Harbor	Glenn A. Black Laboratory Archaeological file	Outside impact area	
12 Pr 1	"La Petite Fort", a French outpost, 1750's	ca. 4½ miles east of Burnes Waterway Harbor	Glenn A. Black Laboratory Archaeological file	Outside impact area	
12 Pr119	Prehistoric, Historic scatter from "blowout"	ca. 5½ miles east of Burnes Waterway Harbor	Glenn A. Black Laboratory Archaeological file	Outside impact area	
12 Pr120	Human Skeletal material from "blowout"	ca. 6½ miles east of Burnes Waterway Harbor	Glenn A. Black Laboratory Archaeological file	Outside impact area	
12 Pr121	Prehistoric lithics recovered from "blowout"	ca. 7½ miles east of Burnes Waterway Harbor	Glenn A. Black Laboratory Archaeological file	Outside impact area	
	Barker Civic Center, Mansion Michigan City	Michigan Harbor	On the National Register	none	In project vicinity (Not listed as impacted harbor)
	Michigan Central Railroad Engine repair shop Michigan City	Michigan Harbor	On the National Register	none	In project vicinity (Not listed as impacted harbor)
	Michigan City Lighthouse, Michigan City	Michigan Harbor	On the National Register	unknown	Not listed as impacted harbor
	Joseph Billy Homestead Indiana Dunes National Lakeshore, Porter Indiana	Burnes Waterway Harbor	On the National Register	none	Outside of impact area, but in project vicinity
	Marktown Historic District East Chicago	Gary Harbor	On the National Register	none	Outside of impact area, but in project vicinity
	Miller Town Hall, Gary Indiana	Gary Harbor	On the National Register	none	Outside of impact area, but in project vicinity

Indiana:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
	John Stewart Settlement Harbor	Gary Harbor	On the National Register	none	Outside of impact area, but in project vicinity

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Michigan

The shorelines of the Upper and Lower Peninsula of the State of Michigan encompass approximately two-thirds of the exposed shoreline of the Great Lakes-St. Lawrence Seaway Navigation System potentially affected by this project.

Initial contact with the Michigan archaeological community was made through the office of the State Historic Preservation Officer. The State Archaeologist has at least three forms of data readily available to him. First, the archaeological sites for each county are listed by township, with townships in alphabetical order. These county site files are now in the process of being set in a computerized format. All sites listed in the site files have been plotted on U.S. Geological Survey (USGS) topographic quadrangle maps to give an impression of the general topographic situation of the area in which the site is believed to have been found. The State Archaeologist's office also has some of the more recent site and survey reports which have resulted from projects it has funded and those accomplished by the University of Michigan, Michigan State University, Western Michigan University, and Northern Michigan University, the major institutions in the state producing archaeological reports.

U.S. Geological Survey topographic quadrangle maps were used in assembling site information. From these quadrangles, site numbers were listed that appeared to be on lakeshore locations or that were in close proximity to the lakeshore. More complete information concerning these sites was then retrieved from the county site files. Information relating to all shoreline archaeological sites from both the Upper and Lower Peninsula was collected in this initial stage of the records and literature search. Site information concerning specific harbor areas which stand in the greatest chance of impact, was later gleaned from a more comprehensive list of shore and harbor sites.

The state of Michigan's site material is well organized, and efforts are being made to improve the lack of information within the site file. Amateur and professional archaeological surveys of the late nineteenth and early twentieth centuries provide only general site locations, some referenced only to section, tier, and range, making it difficult to discern precise locations of many sites. A site that appeared to be on the shore might actually be several hundred meters away. This situation required inclusion of all sites that stood the slightest chance of being adjacent to the lakeshore of a harbor area.

The site files are also incomplete in two other respects. The State Archaeologist's files contain the majority of presently known sites but are incomplete for Berrien Bay, Macomb, Wayne and Monroe counties. At present, the office of the State Archaeologist has not completed a records collection effort from the University of Michigan, Great Lakes Range of the Museum of Anthropology site files. The latter institution presently processes the assignment of new site numbers, and until the development of Cultural Resource Management work was the only set of files extant in the state.

The other problem concerns the fact that many of the sites listed in the state site files lack bibliographic or other source information to substantiate their presence. Knowledge of a large number of the sites' existence is based solely on reference in Wilbert B. Hinsdale's 1931 publication, Archaeological Atlas of Michigan. More recent attempts to relocate some of the sites Hinsdale mentions have proven unsuccessful. This fact has only added to the confusion because some of Hinsdale's sites have been given duplicate site numbers.

To identify historic structures which could lie in impact areas, the Michigan History Division's historic structures personnel specialists were presented with a listing of harbors and connecting waterways

under consideration for extended winter navigation. They then provided historic structure information available on these areas.

Both the archaeological and historic structure information was checked against the most recent copy, February 6, 1979, of the National Register of Historic Places, to complete and up-date the inventory.

There does not appear to be a systematic survey of sites along the entire Michigan lakeshore facing the various Great Lakes. On the whole, knowledge of site information has been synthesized from innumerable excavations and survey reports produced over the last one hundred years. There are possibly four areas for which there exists a report describing the results of a systematic survey for that area. These areas are: Pictured Rock National Shoreline, Sleeping Bear Dunes National Lakeshore, the Garden Peninsula in the Upper Peninsula, and the St. Ignace area.

Knowledge concerning historic structures is also incomplete. Detroit, Marquette, and St. Ignace have experienced some historic structure survey work, but the information from these areas is incomplete. It is the opinion of the State of Michigan's historic structures specialist that all harbors being studied for navigation season extension need additional systematic historic inventory work.

Archaeological and historic structure information on harbors and connecting channels associated with extended winter navigation is provided below.

Presque Isle

It appears that there will be relatively little impact taking place at Presque Isle Harbor. The presence of thermal effluent from

the Upper Peninsula Generating Co. in the dock area negates the need for the installation of a dock air bubbler system. The solid ice situation of the harbor, however, precluded the effectiveness of an ice boom structure. It will be necessary for an icebreaking tug to assist ships from the lake to the dock area.

Marquette Harbor

The cultural resource impact questions which need attention in the Marquette Harbor include the movement of ice by icebreakers and the construction of a building to house a compressor for the air bubbler system. A major factor to be considered is the presence of the Marquette Ore docks, which are on the National Register of Historic Places. A quantum increase in winter icebreaking activities stands a significant chance of impacting the docks. All icebreaking activities should consider this factor before pursuing a plan of action which could be detrimental to the structural stability of the docks.

Information regarding historic structures and shipwrecks needs consideration before implementation of the extended season navigation plan.

It is believed that no archaeological sites will be impacted because the area has already been altered by industrial and urban development of the city of Marquette. But, the construction of a building to house an air compressor could turn up a buried site. If such a circumstance arises, a professional archaeologist would be called in for consultation. This suggestion can be assumed for all land construction activities from this point.

St. Marys River

The St. Marys River plans include the installation of an extensive series of air bubbler systems, plus the anchoring of an ice boom at the head of the Little Rapids Cut. A considerable amount of dredging is also expected to take place.

Discussion of a Demonstration Program conducted on the St. Marys River suggests that the potential for impact along this 75 miles of constricted waterway is high. The continuous movement of vessel traffic has the potential to significantly increase shoreline erosion, plus increase ice damage to shoreline structures.

From the headwaters of the St. Marys River above Sault Ste. Marie to Detour Passage, there are at least ten sites which could possibly be impacted by increased ice movement and possible shore erosion. These sites include both prehistoric and historic sites, and further investigation would be made during post authorization stages of the Program.

Actually, damage done by the air bubbler system would be minimal with respect to cultural resources. But the air bubbler systems proposed for the St. Marys River system would require the construction of at least five buildings to house compressors to run the bubbler systems. These areas would be surveyed for archaeological sites, both prehistoric and historic, prior to construction.

It would also be determined if the proposed dredging material disposal area south of the Detour Passage contains any shipwrecks that could be detrimentally affected by disposal activities.

Port Dolomite

It appears that the opportunity for impact would not be significant at Port Dolomite. There could be a potential noise vibration resulting from increased engine rpms. This effect on shore structures would need to be identified during an operational phase of the program.

St. Ignace

St. Ignace would be the base of operation for one, possible two, U.S. Coast Guard icebreakers. Facilities at the St. Ignace Harbor would require improvements to maintain these vessels at this port. Any alterations in the port area should take into consideration the cultural resources which could be potentially impacted. Archaeological sites, historic structures and shipwrecks could possibly need further identification.

Port Inland

Factors that require consideration at Port Inland are the same as those at Port Dolomite.

Escanaba

Escanaba is one of the more important ports in the Upper Peninsula of Michigan when one considers the quantity and diversity of the products the port receives and ships. Extended season navigation has been attempted at Escanaba with moderate success. Petroleum has been brought into the port, and taconite has been removed.

To improve the winter navigation season conditions, approximately 17,000 feet of air bubbler systems would be installed. These new facilities would require the construction of several buildings to house compressors for the air bubbler systems. Potential impact with respect to archaeological sites and historic structures would be taken into consideration during the post authorization phase.

Muskegon and Ludington

The ice conditions and harbor situations are similar enough that these two ports can be considered together. Both ports are situated on small inland lakes. There may be a number of archaeological sites, both prehistoric and historic, along the shore of the two lakes (Muskegon-Lake Muskegon; Ludington-Pere Marquette Lake). On Lake Muskegon there is already considerable movement of ice by tugs. Potential shore scouring by forced ice movement is a major concern if the archaeological sites are still present. A further records check would be undertaken to determine the state of these sites.

Traverse City

There are several archaeological sites on the shore of Grand Traverse Bay. The present day conditions of these sites is not known, based on a records search. All questions concerning these sites should be considered if major harbor alterations are to be undertaken.

Also of concern is the increased amount of vibration from more frequent icebreaker movement. A comprehensive survey of historic structures along the shoreline would be undertaken in Traverse City, to be considered during the post authorization phase of the program.

Alpena Harbor

There are three docking areas of concern in the Alpena Harbor. The only suggested aid to assist ships in and out of these docking facilities would be an icebreaking tug. The icebreaking tug would also assist ships through ice to the mouth of the Thunder Bay River. Attempts would be made to keep the docking facilities operational in the Thunder Bay River with the aid of two 1,000 foot sections of a dock air bubbler system.

Matters of concern are the results of forced ice movement, i.e., vibration and the construction of a building(s) to house compressor(s) for the air bubbler system. Concerns include potential damage to historic structures and archaeological sites as a result of extended winter navigation.

The site files of the State Archaeologist of Michigan indicate the presence of an archaeological site on the north bank, near the mouth of the Thunder Bay River. This site was originally recorded in 1903, but the present-day condition of the site is not known. If it is extant, it could be subject to ice scour from icebreaker activities. This, and other questions about the state of cultural resources in the Alpena Harbor area would be investigated during post authorization stages of the program.

Another element of concern in the Alpena Harbor area and Thunder Bay is the presence of numerous shipwrecks. Some attempts have been undertaken to inventory the wrecks in Thunder Bay, but is far from complete. Further studies may be required to determine the effect of icebreaking activities on these structures.

Saginaw Bay - Saginaw River Harbor

The harbors on the Saginaw River are scattered along a 17 mile

stretch between Bay City and the city of Saginaw. Navigation of the Saginaw River during the winter months would require the aid of an icebreaking tug. Possible river impacts include vibration, increased erosion as a result of ice movement, and the location of the disposal area for the dredged material from dredging activities should be considered for potential damage to cultural remains (on land-archaeological sites and lake shipwreck sites).

The mouth of the Saginaw River lies in Bay county. The State Archaeologist's office has not completed a records collection effort from the University of Michigan, Museum of Anthropology, site files. Therefore, knowledge of cultural resources for this portion of the study area is limited. The records for Saginaw County would also be thoroughly analyzed before implementation of extended winter navigation.

There are four archaeological sites in Bay County that could be in a position to experience possible impacts from proposed extended winter navigation activities. All four sites are near the mouth of the Saginaw River. Confirmation for two of these sites occurred as late as 1977, but the actual condition of these sites is not known. These sites could be affected by icebreaking activities and the anchoring of the ice boom proposed for Saginaw Bay.

St. Clair River Harbors

The State Archaeologist's site files show the presence of a concentration of archaeological sites, both prehistoric and historic in nature, around the headwater of the St. Clair River at Port Huron. Due to the nature of ice conditions in this area and the early stage planning information, it appears that these sites are not likely to be affected. Some damage could be incurred from the shore anchoring of ice boom structures.

Much of the shoreline of the St. Clair River is protected by riprap of steel, wood, or stone. These areas are thus protected from erosion and detrimental ice movements, except under extreme conditions. More detailed information on the positioning of riprap and structures would be determined so the possible effects of ice movement damage to cultural resources could be more accurately plotted.

The main area of concern is along the lower St. Clair River. Frequent ice jams form in the vicinity of Stag Island. This area is not well represented in the State Archaeologist's site files. If the shoreline in this area is not adequately protected, cultural resources could be impacted. This would pertain to both archaeological sites and historic structures. Any destructive effects of the 1500 foot training wall off the north end of Stag Island would also be addressed.

The only concern with respect to Lake St. Clair would be the location of the future disposal site for dredging spoils.

Detroit River Harbors

At present, shipping occurs throughout the winter on the Detroit River. Proposed plans under the navigation season extension project are mainly designed to prevent delays in shipping traffic movement due to ice jams at several points on the river, most notably, the Peach-Belle Isle vicinity. To prevent these ice jams, a series of ice booms would be installed up river from Peach Island. Placement of shore anchors would be such that they would not endanger any cultural resource. The placement of the ice boom system would take into consideration impacts on Belle Isle, downriver from the ice boom system. The entire expanse of Belle Isle, including the bridge which connects it to Detroit, is on the National Register of Historic Places.

The placement of two 1500 foot training walls, parallel to one another, below the ice boom system could have an adverse effect on the flow rate at the north end of Belle Isle. Protective riprap structures would be considered to prevent any increase in shoreline erosion.

Much of the harbor areas in the Detroit metropolitan area has been built on fill material. In some areas, the original shoreline is in excess of 100 feet west of its present delineations. Therefore, it is not likely that any cultural resources would experience impacts in a large part of the harbor area. Specific areas would be identified where the potential for impact could still exist.

Keeping the Detroit River harbors open includes provisions to assure the navigability of several smaller channels and river connections. This is done with the assistance of an icebreaking tug(s) and a U.S. Coast Guard icebreaker.

An area of concern is the Trenton Channel. The Trenton Channel passes between the south suburbs of Detroit and Grosse Isle. There is an historic district on Grosse Isle on the east side of the inland which would be protected during post authorization design stages.

Placement of dredged materials would be such that there is no potential for damage to cultural and environmental resources. However, no significant dredging is contemplated for this area.

Monroe Harbor

Monroe Harbor will be kept operational with a combination ice-breaking tug and dock air bubbler system. The icebreaking tug will assist ships from Lake Erie into the River Raisin and to the docking facilities.

A records search indicated that two archaeological sites were reported in Hinsdale's Archaeological Atlas of Michigan (1931). They could not be relocated by Brose and Essenpreis (1976), so it can be assumed they have been covered with fill and destroyed.

The air bubbler system would require the construction of two buildings to house compressors for the air bubbler system. These sites would be investigated for archaeological values.

Also, more frequent use of icebreaking tugs would create increased noise pollution (i.e., vibration). There is potential for impact on historic structure in the harbor area if they are extant. A historic structure inventory may be necessary to assure the protection of these cultural resources.

MICHIGAN UPPER PENINSULA

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Huron Islands Lighthouse	Lighthouse	NW of Big Bay Lake Superior	On the National Register	unknown	Depends on shipping route.
Stannard Rock Lighthouse	Lighthouse	Off Keweenaw Peninsula			
20 MQ 18	Historic burials	Squaw Beach	Not on the National Register	unknown	Marquette Co. Historical Society, Michigan Archaeologist, Vol. 2, No. 8, 1956
20 MQ 11	Unknown	Presque Isle Park	Not on the National Register	none likely	
20 MW 3	Unknown	Indefinite location	Not on the National Register	none likely	
Eagle River	Historic buildings	Eagle River	Not on the National Register	unknown	Fragile townsite, many buildings remain from mining port days.
Holy Redeemer Church	Historic Church	Eagle Harbor	On the National Register	unknown	
20 MQ 12	Village	Marquette	Not on the National Register	none likely	Probably destroyed
Marquette Ore Docks	Ore Docks	Marquette harbor	On State Register of Historic Places, Historic American Engineering Record, Nominated to National Register	Potential impact	

Michigan U.P.:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
	Au Sable light station	Grand Marias vicinity	On the National Register	impact possible	
Whitefish Point Lighthouse	Lighthouse	Whitefish Point Chippewa Co.	On the National Register	unknown	
20 CH 86	Historic village and Battleground	Point Iroquois on coast	Not on the National Register	impact	
Point Iroquois Light Station	Lighthouse	5 miles N.W. of Brimley	On the National Register	unknown	
20 CH 22	Unknown	Back Bay coast at Bay Mills	Not on the National Register	impact	
20 CH 14	Village of unknown period	Back Bay coast across from Bay Mills	Not on the National Register	impact	
Elmwood	Henry Schoolcraft House	E. Portage Av.	On the National Register	impact	Being moved but badly undermined by River at present
20 CH 23	Unknown, period undetermined	Coast of St. Mary's River	Not on the National Register	impact	
20 CH 21	Historic, undetermined period	Coast of St. Mary's River	Not on the National Register	impact	Above Brush Point behind light.
20 CH 17	Unknown Site	Waiska Bay	Not on the National Register	impact	Along St. Mary's River
20 CH 20	Historic Dump	Waiska Bay	Not on the National Register	impact	
20 CH 28 20 CH 51 20 CH 56 20 CH 76 20 CH 77	Miscellaneous sites	Sault Ste. Marie	Not on the National Register	impact possible	All sites are shown within the city and not on the coast and impactable by extended navigation practices

Michigan U.P.:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 CH 24 20 CH 25	Both historic of undetermined period (surface scatter)	Sugar Island in St. Mary's River	Not on the National Register	Impact if old channel of St Mary's River used	Located on north coast of Sugar Island
20 CH 78	Historic Sawmill	West coast of West Neebish channel, Oak Ridge	Not on the National Register	possible impact	
20 CH 44 20 CH 71	Middle Woodland seasonal camp	Drummond	Not on the National Register	possible impact	One site, 2 numbers
S.S. Valley Camp	Unknown	Sault Ste. Marie	On the National Register	unknown	Old Union Carbide dock
St.Mary's Falls Canal	Canal	St. Mary's River	On the National Register, National Historic Landmark	possible impact	
20 CH 55	Old Fort Drummond (historic)	W. end Drummond Island	On the National Register	unknown	On coast of Whitney Bay
St. Martin Island	Indian burial ground	Coast of Big St. Martin Island	Not on the National Register	possible impact	Map shows Indian burial ground but no state site number shown
20 MK 56	Subsurface site of unknown occupation of Archaic and Modern stages.	St. Ignace	Not on the National Register	possible impact	
20 DE 4	Multi component middle and late Woodland	Summer Island, Summer Harbor	On the National Register	possible impact	
20 DE 19	Historic iron smelting town	Fayette	On the National Register	possible impact	

MICHIGAN

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 OT 55	Burial mounds; Woodland	Grand Haven	Not on the National Register		May be impacted already--location is in the area of a freeway interchange
20 OT 86	Historic Potowatomi camp	Grand Haven	Not on the National Register	unlikely	Site lies north of the harbor channel protected by cement barrier
20 OT 82	Fur trading post--Louis Campau	Grand Haven	Not on the National Register	none	Site lies within the developed area of Grand Haven--destroyed
20 OT 83	Trading post: Rix Robinson; historic 1820's -'30's	Grand Haven	Not on the National Register	none	Site lies within the developed area of Grand Haven--destroyed
20 MU 8	Village or camp; Woodland	Muskegon	Not on the National Register	unknown	Not precisely located
20 MU 17	Historic Potawatomi village and burial ground	Muskegon	Not on the National Register	unknown	Not precisely located
20 MU 30	John Baptiste Recollect trading post, 1812	Muskegon	Not on the National Register	none	
20 MU 25	Daily Baddeau trading post, 1830's	Muskegon	Not on the National Register	none	
20 MU 26	Historic Indian and white cemetery	Muskegon	Not on the National Register	unknown	Not precisely located
20 MU 27	George Campau trading post, 1833-1835	Muskegon	Not on the National Register	none	
20 MU 28	Joseph Toutier trading post, 1830's	Muskegon	Not on the National Register	none	

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 MU 24	William Lasley trading post, 1830's	Muskegon	Not on the National Register	none	Not precisely located
Muskegon County, Historic District	bounded roughly by Clay, Muskegon 2nd, and 6th sts.	Muskegon	On the National Register	impact may occur from ice-breaking vibration	
20 MN 48	Campsite, period unknown	Ludington	Not on the National Register	unknown	Not precisely located
20 MN 66	Willage, period unknown	Ludington	Not on the National Register	unknown	Not precisely located
20 MN 64	Campsite, period unknown	Ludington	Not on the National Register	unknown	Not precisely located
20 MN 88	Nindebatatunning, historic Ottawa village	Ludington	Not on the National Register	unknown	Not precisely located
20 MN 52	Old Indian clearing, usage undetermined	Ludington	Not on the National Register	unknown	Not precisely located
20 MN 63	Historic Ottawa cemetery	Ludington	Not on the National Register	unknown	Not precisely located
20 GT 32	Mound; period unknown	Traverse City	Not on the National Register	unknown	Amateur reports that the site may be destroyed
20 GT 33	Mound; period unknown	Traverse City	Not on the National Register	unknown	Not precisely located
20 GT 24	Village or mounds; period unknown	Traverse City	Not on the National Register	unknown	Not precisely located
20 GT 27	Mound; period unknown	Traverse City	Not on the National Register	unknown	Amateur report states the site may be destroyed

Michigan: continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 GT 30	Mound; period unknown	Traverse City	Not on the National Register	unknown	Amateur report states the site may be destroyed
20 GT 31	Three mounds; period unknown	Traverse City	Not on the National Register	unknown	Amateur report states the site may be destroyed
20 GT 23	Village; period unknown	Traverse City	Not on the National Register	unknown	Amateur report states the site may be destroyed
20 GT 37	Mound; period unknown	Traverse City	Not on the National Register	unknown	Not precisely located
20 GT 22	Cemetery; period undetermined	Traverse City	Not on the National Register	unknown	Not precisely located
20 GT 28	Mound; period undetermined	Traverse City	Not on the National Register	unknown	Not precisely located
20 Em 13	Village; period undetermined	West of Mackinaw City area	Not on the National Register	unknown	Not precisely located; if the site still exists, it could be damaged by ice scouring--UMM site files
20 EM 11	Village; period undetermined	West of Mackinaw City area	Not on the National Register	unknown	Not precisely located; if the site still exists, it could be damaged by ice scouring--UMM site file Hinsdale, 1931
20 EM 12	Six burial mounds along the shore; Woodland	West of Mackinaw City area	Not on the National Register	unknown	Not precisely located; may be affected if ice scouring increases significant UMM site file
20 EM 50	Undetermined occupation	West of Mackinaw City area	Not on the National Register	unknown	Not precisely located

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 EM 51	Undetermined occupation	West of Mackinaw City area	Not on the National Register	unknown	Not precisely located
20 EM 52	Ft. Michilimackinac, historic Britich fort	Mackinaw City	On the National Register	possible	Increased ice movement from ice-breaking activity could caused increased erosion along the adjacent shoreline
20 MK 1	Juntenan site, multi-phase seasonal fishing village; Late Woodland	Bois Blanc Island	On the National Register	Possible ice erosion increases significantly	This site has undergone major excavation activity--McPherron, 1967
20 MK 83	Arrow head Drive; Middle Woodland burial	Bois Blanc Island	Not on the National Register	unknown	Not precisely located
20 MK 11	Ossuary, undetermined occupation	Round Island	Not on the National Register	unknown	Not precisely located
20 MK 3	Village of camp; period undetermined	Round Island	Not on the National Register	unknown	Not precisely located
20 MK 10	Village; period undetermined	Mackinac Island	Not on the National Register	unknown	Not precisely located--site is not located any closer than township and range
20 MK 64	Fort Garden site; undetermined occupation; historic	Mackinac Island	Not on the National Register	unknown	Not precisely located--site is not located any closer than township and range
20 MK 66	Robinsons Folly; undetermined occupation, Archaic	Mackinac Island	Not on the National Register	unknown	Not precisely located --site is not located any closer than township and range

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 MK 69	MIS-14; undetermined occupation, Archaic	Mackinac Island	Not on the National Register	unknown	Not precisely located--site is not located any closer than township and range
20 MK 73	MIS-21; undetermined occupation; historic	Mackinac Island	Not on the National Register	unknown	Not precisely located--site is not located any closer than township and range
20 MK 79	MIS-30; undetermined occupation; historic	Mackinac Island	Not on the National Register	unknown	Not precisely located --site is not located any closer than township and range
	Old Presque Isle Lighthouse	Presque Isle	On the National Register	unknown	Could be damaged by increased ice movement
	Mackinac Point Lighthouse	Michilimackinac State Park, Mackinaw City area	On the National Register	unknown	Could be damaged by increased ice movement
20 AL 27	Historic village and cemetery	Alpena, near the mouth of the Thunder Bay River	Not on the National Register	unknown	Not precisely located
20 BY 6	Kerr 3; burial mound Woodland	Bay City, near the mouth of the Saginaw River	Not on the National Register	unknown	Not precisely located
20 BY 23	Kerr 4; village period undetermined	Bay City, near the mouth of the Saginaw River	Not on the National Register	unknown	Not precisely located
20 BY 27	Village, period undetermined	Bay City, near the mouth of the Saginaw River	Not on the National Register	unknown	Not precisely located

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 BY 21	Village; period undetermined	Bay City (Saginaw River)	Not on the National Register	unknown	Not precisely located
	Grindstone City Historic District	Grindstone City on U.S. 25	On the National Register	unknown	
	Point Aux Barques Lighthouse	Huron City vicinity	On the National Register	unknown	Could be damaged by increased ice movement
20 HU 63	Lighthouse Petroglyphs, Archaic	Port Austin	Not on the National Register	impact likely	Increased ice movement could scour Petroglyphs off it's rock surface
	Sanilac Petroglyphs	Port Sanilac	On the National Register	impact likely	Increased ice movement could scour Petroglyphs off it's rock surface
20 SC 8	St. Clair River Site, multi-stage village and burial ground; Early-Late Woodland	Mouth of the St. Clair River Port Huron	Not on the National Register	unknown	Site dimensions are not adequately defined
20 SC 7 20 SC 40					Subdivision(s) of 20 SC 8
20 SC 61	Fort Joseph; historic French Fort, 1686-1688	Port Huron, Gratiot Park	Not on the National Register	unknown	
20 SC 41	Fort Gratiot, historic military fort, 1814-1879	Port Huron	Not on the National Register	unknown	
20 Sc 42	T.E. Edison Depot, train depot, extant structure	Port Huron		unknown	Structure could be damaged by icebreaker vibration

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACTS	COMMENTS
20 SC 43	Grand Truck Western Railroad repair shops-extant structure	Port Huron	On the National Register	unknown	Structure could be damaged by icebreaker vibration
20 SC 34	Burial mound; period undetermined with intrusive Chippewa burial (historic)	Port Huron	Not on the National Register	unknown	
20 SC 10	Anmichoanaw's village, historic	Port Huron	Not on the National Register	unknown	
	Fort Gratiot Lighthouse	Port Huron	On the National Register	unknown	Impact may occur from increased ice movement and icebreaker vibrations
	Huron (Lightship)	Port Huron, Pine Grove Park on the St. Clair River	On the National Register	unknown	Impact may occur from increased ice movement and icebreaker vibrations
20 SC 61	Fort Joseph; historic French Fort, 1686-1688	Port Huron, Gratiot Park	Not on the National Register	unknown	
	St. Clair River Tunnel	Port Huron, St. Clair River between Port Huron, MI and Sarnia, Ontario	On the National Register	unknown	Impact could possibly occur from downward thrusted ice (by icebreakers)
20 SC 65 (20 SC 5)	Burial ground; historic	Marysville area	Not on the National Register	unknown	Site proximity to the shore is not known
20 SC 52	Cemetery; period undetermined	St. Clair area	Not on the National Register	unknown	Site proximity to the shore is not known

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 SC 58	Fort St. Clair historic	St. Clair area	Not on the National Register	unknown	Site proximity to the shore is not known
20 SC 38	Kroon's Landing, historic Euroamerican fishing station	Marine City area	Not on the National Register	unknown	Site proximity to the shore is not known
20 SC 2	Harsens Island burial ground	Algonac area	Not on the National Register	unknown	Site proximity to the shore is not known
20 SC 6	Algonac; burial mound; Woodland	Algonac area	Not on the National Register	unknown	Site description lists the mound as "potted"--probably destroyed
	Fort Wayne; historic fort	Detroit, on the Detroit River	On the National Register	unknown	Could be subject to icebreaker vibration
	"site" includes the entire island, all structures and bridge to the mainland	Belle Isle, the Detriot River	on the National Register	impact likely	ice jams regularly form in the Belle Isle vicinity, removal of these jams could be detrimental to the island's stability
	East River Road Historic District	E. River Rd. Grosse Isle	on the National Register	impact likely	impact considerations similar to that of Belle Isle
	Indian Village Historic District	Detroit, bounded by Mack, Burns, Jefferson and Seminoles Ave.	on the National Register	impact likely	Michigan Historic Division lists the districts as a coastal area of particular concern
20 MR 223	Undetermined usage; Archaic and Lake Woodland components	Sterling State Park, near the River Raisin, Monroe	Not on the National Register	Impact ongoing	

Michigan:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
20 MR 224	Undetermined usage; Archaic and Late Woodland components	Sterling State Park, near the River Raisin, Monroe	Not on the National Register	Impact ongoing	
20 MR 23		Near the mouth of the River Raisin, Monroe	Not on the National Register	unknown	Recent survey (Brose & Essenpeis, 1973) could not relocate the site
20 MR 24		Near the mouth of the River Raisin, Monroe	Not on the National Register	unknown	Recent survey (Brose & Essenpeis, 1973) could not relocate the site - - - - - - - - - - - MR 223 & 224 and MR 23 & 24 could be the same pairs of sites
20 MR 151	Fishing village and cemetery: Late Woodland and historic com-	Indian Island, near Toledo	Not on the National Register	unknown	Potential for impact exists because of the island's proximity to the Toledo harbor channel
20 MR 152 156 20 MR 158 20 MR 159 20 MR 218 19		Indian Island, near Toledo	Not on the National Register	unknown	Potential for impact exists because of the island's proximity to the Toledo harbor channel
20 MR 161 162 20 MR 164 20 MR 221		Gard Island, near Toledo	Not on the National Register	unknown	Potential for impact exists because of the island's proximity to the Toledo harbor channel
20 MR 165	Undetermined usage; Middle Woodland	North Cape-tip end of the W Woodstick Peninsula	Not on the National Register	unknown	Potential for impact exists because of the island's proximity to the Toledo harbor channel

LIST OF ABBREVIATIONS-BASED ON THOSE USED BY THE MICHIGAN HISTORY DIVISION'S ARCHAEOLOGICAL SITES FILES AND ANNOTATED BIBLIOGRAPHY

AJSA	American Journal of Science and Arts
AMER ANT	American Antiquity
AMER MUS JRNL	American Museum Journal
BAE BULL	Bureau of American Ethnology, Bulletin
FIELDIANA	Fieldiana-Anthropology
MHD	Michigan History Division
MHD-ASR	Michigan History Division Archaeological Survey Report
MHPA	Michigan Historical Publishing Association
MICH ARCH	The Michigan Archaeologist
MICH HIST	Michigan History Magazine
MISPC	Mackinac Island State Park Commission
MISPC-ACRS	Mackinac Island State Park Commission Archaeological Completion Report Series
MPHC	Michigan Pioneer and Historical Collections
MSUM	Michigan State University Museum
MSUM-ASR	Michigan State University Museum Archaeological Survey Report
PAAAS	Proceedings of the American Association for the Advancement of Science
PMASAL	Papers of the Michigan Academy of Science, Arts and Letters
RMHA	Reports in Mackinac History and Archaeology
SCS	Soil Conservation Service, USDA
SI-AR	Smithsonian Institution, Annual Report
UMMA	University of Michigan Museum of Anthropology
WISC ARCH	The Wisconsin Archaeologist
WMU	Western Michigan University

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Ohio

The main repositories for curtural resource information in Ohio are the Ohio Historical Society Staff Offices at the Ohio Historical Center in Columbus, Ohio. The Historical Center is the central repository for all cultural resource documentation from each Regional Historic Preservation District Office. The regions concerned with the Lake Erie coastline of Ohio are Region 1HA based at the Toledo Museum of Natural History and Region 2HA based at the Cleveland Museum of Natural History. The Ohio Historical Center houses a fine interpretive museum of the prehistory and history of the region, as well as departments of Archaeology, History, and Natural History.

The Department of Archaeology provided information from the files of the Ohio Archaeological Inventory (OAI). The OAI files include site information forms for each recorded archaeological site in the state, which are also plotted on U.S.G.S. 7.5' minute series topographic maps. In addition, an information file is maintained by county, including all relevant documentation concerning archaeological investigations in the area such as newspaper articles, reports, photos, and correspondence. These records were intensively investigated for the harbors concerned in this study.

The Department of History also maintains a similar inventory of Historic sites. The Ohio Historical Inventory (OHI) officer aided greatly in obtaining the relevant county files and reducing the massive amount of recorded historic sites to those sites adjacent to the harbor areas. Other individuals were contacted concerning archaeological or historical sites within and adjacent to the harbors in their regions. Through contact sources and investigations of the OAI, OHI, and county files, a considerable amount of pertinent data for the Lake Erie project harbors were acquired. However, in many areas surveys have not been conducted and no information exists documenting

cultural resources. Even in areas where fairly extensive cultural resource recording has occurred, the documentation must be considered incomplete. The known sites indicate the potential for additional undiscovered or unrecorded sites and structures in the areas not adequately investigated. Therefore, the lack of documentation does not imply negative evidence, but rather a deficiency in the level of cultural resource documentation.

Nine harbors, in seven counties on the Ohio Shore of Lake Erie, were investigated in this portion of the Great Lakes Navigation Season Extension Study. The harbors and the extent of documentation of cultural resources for each is briefly discussed as follows. Cultural Resources are listed in the tables at the end of this section.

The archaeological data base for each harbor is sparse. This is a result of over a century of intensive ongoing industrial development and improvement in each harbor area. Most archaeological sites were destroyed before they were recorded. Some site locations are mentioned in early documents, and Indian villages in the harbors were often reported in early French or English explorers' documents. Cleveland Harbor and Huron Harbor had no recorded archaeological sites. Toledo Harbor, Marblehead Harbor, Sandusky Harbor, Lorain Harbor, Fairport Harbor, Conneaut Harbor and Ashtabula Harbor each had at least one prehistoric site recorded. No harbor had more than five archaeological sites recorded in its vicinity. In many cases the sites have been destroyed or their locations lost. These few recorded sites represent only a fraction of the archaeological sites which have existed in the harbor areas. The natural features of the harbors, offering protected waters in proximity to the resources of the lake at the mouths of various rivers, would have made these areas desirable occupation locations throughout prehistory. Many sites have been destroyed but it is possible that there are sites which remain intact and unrecorded. Therefore, the records of archaeological sites must be considered incomplete.

The historical data base for the Lake Erie south harbors is fairly extensive though by no means does it represent a complete inventory of historic sites in the areas concerned. The activities of local historical interest groups and the Regional Preservation offices as well as various surveys have recorded data on many historic structure sites. Huron Harbor has no recorded historic sites. All of the remaining harbors investigated have at least one National Register site in the harbor vicinity. Most harbors have additional inventoried historic sites without final determinations of their National Register Eligibility. Cleveland Harbor represents the most intensively documented area with nine National Register structures and twelve locations recorded in a Historic American Engineering Record (HAER) survey. Each harbor has the potential for significant historic structures and should be field investigated.

Paleontological resources are not inventoried or recorded in archives in any form comparable to prehistoric and cultural resources in Ohio. The consensus among paleontologists is that there are no specific significant paleontological resources in any of the harbors in northern Ohio. Paleontological resources may exist in some of these locations, but by nature of their occurrence in bedrock strata, the fossils usually remain undiscovered until exposed by some form of activity of an impacting nature.

Concerning underwater shipwreck sites, it was discovered that shipwrecks exist near or within all of the Ohio harbors and that documentation is available and extensive for shipwrecks on the Great Lakes. Shipwrecks by their nature of occurrence tend to cluster around harbors and the problem of investigating the large number of known wrecks will be discussed in a separate section on underwater shipwreck sites.

A cursory bibliography and a complete list of relevant records and resources sources is included.

MARBLEHEAD HARBOR
OTTAWA COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
33 Er 18	Prehistoric Village & Earthwork	South Shore Kelley'sIsland	Nominated to to NRHP Recorded OAI	possible impact	Late Woodland Village site 1200 A.D.
33 Er 19	Prehistoric mound	Northwest Shore Kelley's Island	Destroyed recorded OAI	possible impact	Late Woodland
33 Er 17	Inscription Rock Prehistoric	South Shore Kelley's Island	National Register site State Memorial	possible impact	Petroglyph
33 Er 22	Prehistoric Earthworks	South Shore Kelley's Island	Nominated NRHP recorded OAI	possible impact	Late Woodland Village Site
33 Ot 22	Prehistoric Burial Site	Inland on Catawaba Island Peninsula	Recorded OAI Significance not assessed	none	1500' inland from Lake Erie
Kelley's Island South Shore District	Historic District Prehistoric	Water St. South side of Kelley's Island	National Register	possible impact	
Marblehead Lighthouse		Marblehead point	National Register	none	

TOLEDO HARBOR, TOLEDO OH
LUCAS COUNTY

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACTS	COMMENTS
33Lu154	Multi-component Prehistoric Village site	Niles Beach Lake Erie Shore	Potentially eligible for National Register nomination	possible impact	Site is significant to understanding regional prehistory
Luc 152-9 Joseph Secor House	Residence 1871	311 Bush St. Near Maumee River	Recorded OHI No determination of eligibility made	none	Outside direct impact area
Luc 126-8	Hotel Waldorf 1916	Madison & Water St., near Maumee River	Recorded OHI Not eligible NRHS	none	
Luc 36-8	First Nat. Bank	312 Summit St. near Maumee River	Recorded OHI Not eligible NRHS	none	
Luc 26-8	Toledo Edison Plant ca.1895	Maumee River Front, Toledo Harbor	Recorded OHI Potentially eligible	possible impact	First Electrical plant in Toledo
Luc 159-9	Penn Central Freight Station 1879	1200 Water St. Maumee River Front	Recorded OHI potentially eligible	possible impact	Originally named R.R. Freight House
Luc 50-9	Finlay Brewery 1865	1224 Summit St near Toledo Harbor	Recorded OHI Potentially eligible	none	
Toledo Yacht Club		Bay View Park	National Register	possible impact	
Vistula Historic District		Bounded by Summit Champlain, Walnut Magnolis Sts.	National Register	none	Outside direct impact area

SANDUSKY HARBOR
ERIE COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
33 Ot 16	Prehistoric Village Site	Southern Tip of Marblehead Peninsula Sandusky Bay	potentially eligible for nomination recorded OAI	possible impact	Extensive Archaic period village site
33 Ot 18	Prehistoric Village Site	Southern Tip of Marblehead Peninsula Sandusky	Potentially eligible for nomination to NRHP recorded OAI	possible impact	Extensive Upper Mississippian village site
Anionton Village	Proto Historic Huron Indian village	In vicinity of Bay Bridge, Sandusky Bay	Reported in paper by Charles E. Frohman	unknown	Exact location unknown. See Frohman discussion
Numqunhanty Village	Proto Historic Huron Indian Village	In vicinity of Mouth of Sandusky River	Reported in paper by Charles E. Frohman	unknown	Exact location unknown. See Frohman discussion
The French Fort	Fort built in 1751	In vicinity of the South end of Sloan road in Ottawa Co.	Reported in paper by Charles E. Frohman	unknown	Exact location unknown. See Frohman discussion
Fort Sandusky	Fort built in 1761 English	Present location of Venice in Sandusky	Reported in paper by Charles E. Frohman	unknown	Exact location unknown. See Frohman discussion
ERI-18-3	Cholera Cemetery 1849-1854	Harrison St. Sandusky South Shore of Bay	Recorded OHI	Elevated above impact zone	In use prior to 1830 Cholera epidenic 1849
Johnson Island Fort site	Civil War Prison Fort	East shore of Jonhson Island	National Register	possible impact	

LORAIN HARBOR
LORAIN COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
33 Ln 56	Prehistoric Campsite	Bank of Black River .6m East of 21st St. Bridge	Recorded OAI No assessment	none	Outside impact area
LOR 185-16	Thompson House 1916	Between Erie Av. and Lake Erie	Recorded OHI not eligible	unknown	
LOR 244-16	Myers House 1910	Between Erie Av. and Lake Erie near Bay Drive	Recorded OHI not eligible	unknown	
LOR 18-16	Root House 1834	Between Erie Av. and Lake Erie near Root Road	Recorded OHI eligible for nomination	none	Outside impact area
LOR 179-16	William Root residence 1850	Erie Av. & Root Road	Recorded OHI National Register	none	Outsie impact area
LOR 349-16	Lorain Lighthouse	North edge of West Breakwater	National Register	possible impact	

CLEVELAND HARBOR
CUYAHOGA COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Coast Guard Station	Station and Lighthouse	West Pier West Harbor Entrance	On the National Register	possible impact	*See Dave Bush 1976
Samsel Marine Supply	Manufacturing Industry 1860	1310 W. 11th St.	On the National Register	unknown	On River front *See Dave Bush 1976
Western Reserve Building	1891	9th & Superior	On the National Register	none	Above impact elevation *See Dave Bush 1976
Division Av. Pumping Station		Division Av. on Old River front at end of West 45th	On the National Register	possible impact	*See Dave Bush 1976
Detroit Superior High Level	Bridge	Superior-Detroit Av. accross Cuyahoga River	On the National Regsiter	possible impact	*See Dave Bush
Ohio City Preservation District	Historic District	Several blocks encompassing Fairview Park	On the National Register	none	Outside impact area *See Dave Bush
Lorain Carnegie Bridge	Bridge	Spans Cuyahoga River between Lorain-Carnegie Aves.	On the National Register	possible impact	
Superior Av. Viaduct	Bridge	Superior Av. over Cuyahoga River	On the National Register	possible impact	
Upson-Walton Company Building	Ship building	1310 Old River Rd.	On the National Register	unknown	
Erie Lackawana Ore Dock	Ore unloading dock and facilities 1881	River Road on Old River Bed	HAER	possible impact	Site of first mechanical ore moving equipment
Pennsylvania Railway Ore Dock	Ore unloading dock and facilities	Wiskey Island on Old River	HAER	possible impact	Site of first Hulell unloaders
Corrigan McKinney and Company	Steel and iron manufacture 1910	3100 E 45 St on Cuyahoga River	HAER	unknown	Originally named River Furnance Company--produced Pig lion

Cleveland Harbor
Cuyahoga County, Ohio:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Otis Steel Company	Steel Manufacture 1873	3341 Jennings Rd. on Cuyahoga River	HAER	unknown	Ore Dock
Ferry Cap and Set Acrew Company	Nut and bolt manufacture 1907	2151 Scanton Av. Cuyahoga River	HAER	unknown	
Upson Nut Company	Nut and bolt manufacture 1893	Scranton Av. Cuyahoga River	HAER	unknown	
Globe Ironworks	Maine machine and boiler manufacture 1853	Center and Spruce Sts.	HAER	unknown	Made materials to supply local wooden ship building yards
Ship Owners Dry Dock Company	Ship building and repair 1888	W. 54th St. on Old River Bed	HAER	unknown	Site has been substantially altered
Cleveland Worsted Mills Company	Textile Manufacture 1878	6114 Broadway	HAER	unknown	Outside impact area
Standard Oil	Oil Refining 1865	3635 Broadway	HAER	unknown	Consolidation of many structures
Grasselli Chemical Company	Sulphuric Acid manufacure 1866	2891 Independence Rd.	HAER	unknown	
Sherwin Williams Company	Paint Manufacture 1873	601 Canal St.	HAER	unknown	Large industrial complex along Cuyahoga River

FAIRPORT HARBOR
LAKE COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
33 La 5	Prehistoric Village	Paynesville Twp. east of harbor on Grand River South of Railroad track	Recorded OAI	none	Above impact elevation
Fairport Harbor Museum	Museum	129 2nd St.	On the National Register	possible impact	

CONNEAUT HARBOR
ASHTABULA COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
33 Ab 42	Prehistoric Burial and Village Site	West side of Conneaut Creek at vicinity of Pearl St.	Recorded OAI no determination of significance	unknown	Adena Middle Archaic site limits unknown
33 Ab 44	Prehistoric camp	East Bank of Conneaut Creek at mouth	Recorded OAI not eligible	none	Site has been destroyed by industrial activity
Bennett Campsite #11 in D. Brose Survey Report	Prehsitoric camp	On Lake Erie shore between B & LE Railroad and Tinkey Creek	Reported in Survey Report Cleveland Museum Of Natural History	possible impact	Lake Woodland campsite *See Brose 1977a
Eastwall Site 33 Ab 40	Iroquoian village	On Lake Erie shore near east breakwater wall	Recorded OAI potentially eligible	possible impact	Site has been test excavated *See Brose 1977a
Eastwall Western Knoll	Portion of Iroquoian village	West of 33 Ab 40	Recorded OAI potentially eligible	possible impact	Probably contiguous to 33 Ab 40 *See Grose 1977a
ATB 146-7	Lewis Harper House and Commercial Block	336 Harbor St. 320-332 Harbor St.	Recorded OHI not eligible	no direct impact	
ATB 173-7	Conneaut Viaduct 1924	State Rt 20 over Conneaut Creek	Recorded OHI eligible for nomination	unknown	
ATB 93-7	Conneaut 4-track Swing Bridge 1900	Over Conneaut Creek at the Harbor	Recorded OHI eligible for nomination	possible impact	Largest swing bridge in the world at the turn of the century
ATB 126-7	Marine Saving Bank ca. 1895	Day and Park St.	Recorded OHI eligible for nomination	no direct impact	First bank in harbor district
ATB 127-7	Pittsburg and Conneaut Dock Company 1893	Ford and Pearl Adjacent to harbor	Recorded OHI not eligible	possible impact	1896 Andrew Carnegie bought dock to ship ore for steel mills
ATB 162-7	Salisbury Residence ca. 1830	1392 Lake Rd. on Lake Erie	Recorded OHI not eligible	unknown	
ATB 163-7	Viets Residence ca. 1850	1448 Lake Rd. on Lake Erie	Recorded OHI not eligible	unknown	
ATB 197-7	Harper Residence 1799	379 East Lake Rd on Lake Erie	Recorded OHI eligible for nomination	unknown	
ATB 125-7	Kilpi Hall 1899	1025 Buffalo St.	On the National Register	unknown	

ASHTABULA HARBOR
ASHTABULA COUNTY, OHIO

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Indian Point Site	Prehistoric burial site	On west bluff overlooking Ashtabula River in harbor just north of Lake Rd.			Reported by Bertran S. Kraus-Report in OAI County Files
ATB 26-3	Bridge St. Bascule Bridge	Over Ashtabula River on Route 531	Recorded at OHI eligible for nomination	possible impact	Constructed 1925 joins Ashtabula Harbor commerical district on National Register
AC 54	Harbor Lift Bridge 1925	Over Ashtabula River on Route 531	Recorded at OHI eligible for nomination part of Historic District	possible impact	More than 5 bridges have existed at this location
ATB 38-3	Old Coast Guard House ca. 1871	1071 Walnut Blvd. the "Point" adjacent to harbor	Recorded OHI potential as part of Historic District	no direct impact	Housed Coast Guard lighthouse attendant preservation underway
ATB 77-3	Captains House residence ca. 1890	1084 Walnut Blvd. the "Point" adjacent to harbor	Recorded OHI Part of Historic District eligible for nomination	no direct impact	Captain Myers residence Harbor Historic District
ATB 71-3	Mother of Sorrows R.C. Church	West 6th & Coyne Av	Recorded OHI Part of Historic District not eligible	no direct impact	Harbor Historic District
ATB 76-3	Leona Robertson residence 1890	1205 Walnut Blvd	Recorded OHI Part of Historic District not eligible	no direct impact	Harbor Historic District
ATB 78-3	Ende Residence 1920	1211 Walnut Blvd	Recorded OHI Part of Historic District not eligible	no direct impact	Harbor Historic District
ATB 74-3	Kavela Lodge 1890's	Lake Ave and W 4th St.	Recorded OHI Part of Historic District not eligible	no direct impact	Harbor Historic District Old Finnish Church

Ashtabula Harbor:continued

SITE #	DESCRIPTION	GENERAL LOCATIONS HARBOR	INVENTORY STATUS	POTENTIAL IMPACTS	COMMENTS
ATB 79-3	Tower's Residence ca. 1890	1218 Walnut Blvd.	Recorded OHI Part of Historic District not eligible	no direct impact	Harbor Historic District
ATB 75-3	Robert White Residence ca. 1885	1236 Walnut Blvd.	Recorded OHI Part of Historic District not eligible	no direct impact	Harbor Historic District
	Ashtabula Harbor Commerical District	Both sides of W. 5th from 1200 block to Ashtabula River	On the National Register District	no direct impact	
	Colonel William Hubbard House	Lake and Walnut Av.	On the National Register District	no direct impact	
ATB 92-3	Harbor Railroad Office--Conrail 1910	6th St. at harbor	Recorded OHI not eligible	no direct impact	Formerly VJM Tower named
ATB 86-3	Prentice Residence ca. 1900	1845 Walnut Blvd	Recorded OHI not eligible	no direct impact	Harbor Historic District

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Pennsylvania

The main repository for the cultural resources, both historic and prehistoric, of the Commonwealth of Pennsylvania is the Pennsylvania Historical and Museum Commission. This organization is located in the William Penn Memorial Museum and Archives Building in Harrisburg.

The Office of the State Archaeologist utilized a county filing system for the known archaeological sites. The Erie County file was checked for sites located within and adjacent to Erie Harbor. Additionally, the State Archaeologist was consulted about archaeological sites in the project area.

Several prehistoric archaeological sites are known for Erie County, Pa., some of which are situated within the present day city limits of Erie, Pa. Cultural affiliation for these sites varies from late Paleo-Indian to Lake Woodland. However, the literature and records search failed to reveal any known prehistoric archaeological sites in close proximity to the Erie Harbor. The closest known site, 36 Er 68, was one thousand feet back from the shore.

At least one contact period site, the 28th Street Site, clearly shows European influence in the area as early as the first half of the 17th century (Carpenter, Pfirman, and Schaff 1949). The site is not situated adjacent to the Erie Harbor, but it is indicative of the potential for other contact period sites in the area.

To date, no systematic archaeological investigation has been conducted in the immediate vicinity of Erie Harbor. However, M. Jude Kirkpatrick of Gannon College in Erie, Pa., has received permission to conduct an archaeological reconnaissance of Presque Isle State Park which is a portion of the harbor. The reconnaissance was scheduled to be performed between May 14 and July 13 of 1979.

Information was also sought for historic standing structures and historic sites, such as shipwrecks, that are presently beneath the harbor waters. Office of Historic Preservation for Pennsylvania, was consulted about historic structures within and adjacent to Erie Harbor. The filing system of this office is also by county.

The Erie County Historical and Architectural Preservation Plan (1976) was found to be of much assistance, but this report is not a comprehensive planning document for the harbor area.

Two sunken ships for Erie Harbor were identified in literature, but both ships do not pose any problem in proposed harbor modifications. Both ships were originally on the bottom of Misery Bay, but one, the LAWRENCE, was retrieved in 1975 and the other, the NIAGRA, was retrieved in 1913. The ships served as Perry's flagships during the Battle of Lake Erie.

Due to much rebuilding in the harbor area and modification of the harbor bottom through dredging operations, many historic structures and shipwrecks probably no longer exist. European settlement and development have also undoubtedly destroyed many of the prehistoric archaeological sites. Although alterations have occurred which have destroyed some sites, the Erie harbor lacks a comprehensive survey of historic structures, shipwrecks, and archaeological sites.

The Curator of Earth Science for the Pennsylvania Historical and Museum Commission knew of no specific paleontological sites in the project area. An amateur paleontologist reports that glass sponges (ceratodictya, hydnoceras, and prismodictya) can be found within a few miles of Lake Erie and that the trace fossil bifungites occurs in the Girard shale just south of Erie's city limits. These fossils occur in rocks of Devonian age. Additionally, Devonian corals are found on the Lake Erie beaches, but they apparently are glacial erratics. Pleistocene fossils were not reported by Lamborn for Erie County. No specific fossil localities were reported for Erie Harbor.

PENNSYLVANIA (Erie Harbor)

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACTS	COMMENTS
British Fort Presque Isle	Archaeological site	Near the mouth of Mill Creek		unknown	The fort was destroyed by the French in 1759 after English domination
American Fort Presque Isle	Archaeological site	Garrison Hill within the present ground of the Soldiers'Home		no impact	The blockhouse on this site was built in 1880 by the state as a memorial to General Wayne
Erie Extension Canal	Canal basin and historical marker	Foot of State St.		unknown	The canal basin is presently used by small harbor craft
Perry's Shipyard	Historical marker and archaeological site	Mouth of Cascade Creek		unknown	The Lawrence and the Niagara were built here in 1813
Perry's Shipyard #2	Archaeological site	Garrison Run (foot of Peach St.)		unknown	The remainder of Perry's fleet was built here
Land Lighthouse	Circular structure built of gray cut stone, also archaeological site	Foot of Lighthouse St., in Land Lighthouse Park	Entered in the National Register	no impact	The Land Lighthouse was built on the site of the first lighthouse constructed by the U.S. Government on the Great Lakes
Soldiers and Sailor's Home	Three story brick building with numerous additions	560 East 3rd St.		no impact	This structure was built on the site of the American Fort Presque Isle
Rique	Archaeological site	Somewhere within the present city limits of Erie, Pa.		unknown principally because location is unknown	Palisaded Erie town destroyed by the Seneca in 1656

Pennsylvania:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Presque Isle Lighthouse	Partially brick	Lake side of Presque Isle		no impact	
Perry Monument	Monument	Lake side of Presque Isle		no impact	Erected in 1926
French Fort Presque Isle	Archaeological site	Near the mouth of Mill Creek		unknown	The fort was destroyed by the French in 1759 after English domination
U.S.S. Niagra	Reconstructed brig	Foot of State St.	Entered in the National Register	no impact	Commodore Perry's Flagship
U.S.S. Wolverine (Michigan)	Navy's first iron hulled ship, built in 1843	Foot of State St.		no impact	The ship was dismantled in 1949 and all that remains is the bowspirit

New York State

The main repositories for cultural resources for the state of New York are the Division for Historic Preservation, Agency Building 1, Empire State Plaza, and the Office of the State Archaeologist, New York State Museum, State Education Department.

The files of the Historic Preservation Field Services Department of the Division for Historic Preservation are organized by county. However, the files do not represent a complete inventory of the cultural resources for each county. Information pertaining to respective local historical organizations was obtained from Buffalo Landmark & Preservation Board and the Buffalo and Erie County Historical Society (Buffalo Harbor), the Rochester Museum and Service Center and the Landmark Society of Western New York (Rochester Harbor), and the Oswego County Historical Society and the Heritage Foundation (Oswego Harbor). Information was also received from the Jefferson County Historical Society and the Posdam Public Museum (St. Lawrence County).

The Evaluation of Shore Structures and Shore Erodibility St. Lawrence River New York State (Palm 1977) provides a valuable reference for Historic structures and their exposure to extended navigation impact. This report deals with the islands in the St. Lawrence River that belong to the United States and those areas adjacent to the St. Lawrence River in Jefferson and St. Lawrence Counties. Twenty-six structures were identified as having historic or cultural significance.

The State Archaeologist provided valuable assistance in the location of archaeological sites for Buffalo Harbor, Rochester Harbor, Oswego Harbor, and that portion of the St. Lawrence River belonging to the United States. The Office of the State Archaeologist has information pertaining to historic and prehistoric archaeological sites for the entire state. These data sets are arranged by county. The project areas for the state of New York, however, have never been the subject of a systematic archaeological reconnaissance. Therefore, data for

specific areas is only partially complete; the earliest collected data lacks precise site locations.

Additional archaeological information is available from the Buffalo Landmark and Preservation Board, the Buffalo and Erie County Historical Society (Buffalo Harbor), the Rochester Museum and Service Center (Rochester Harbor) and Dr. Peter Pratt, archaeologist at the State University College at Oswego (Oswego Harbor).

The Buffalo, Rochester, and Oswego Harbors have a common denominator: they were all developed at the mouth of rivers. Areas where rivers empty into major lakes were probably extensively utilized by prehistoric peoples. Such areas also attracted Europeans who greatly modified the landscape of these areas. Early development of these harbor areas and the relative lateness of comprehensive archaeological reconnaissance are primarily responsible for the inadequate data pertaining to the harbor area.

Comparatively, the St. Lawrence River has had little European development, but islands and its shore line have been the subject of only one systematic reconnaissance (Palm 1977). However, this reconnaissance did not include archaeological sites or shipwrecks.

Unlike the St. Lawrence River, comprehensive historical structure surveys are lacking for the Buffalo, Rochester, and Oswego Harbors. Data on shipwrecks are also lacking for these harbors. Undoubtedly, some of these shipwrecks have been destroyed through dredging operations but others may remain.

Investigation of the paleontology of the Buffalo, Rochester and Oswego Harbors, and the United States portion of the St. Lawrence River began with contacting the New York Geological Survey State Paleontologist. Disturbance to paleontological sites has occurred in each of the harbor areas since the arrival of the Europeans.

Most of this disturbance has probably been of a covering nature, which conceals any paleontological sites. In contrast, only a small portion of the St. Lawrence River banks has been altered to such an extent as to conceal deposits. No systematic reconnaissance for paleontological sites has been conducted for any of the New York State project areas.

NEW YORK

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
China-man's Light	75 foot high limestone and bluestone lighthouse	North entrance of Buffalo Harbor, located on property adjacent to the U.S. Coast Guard Station		unknown	
Delaware, Lackawanna, and Western Railroad Terminal	Granite block and brick structure with a tile roof	Main St. and South Park Av.		possibly impacted	
Fort Ontario	Cut stone block wall, pentagonal in plan with five arrow shaped bastions buildings in courtyard	East 7th St. at the confluence of the Oswego River and Lake Ontario	Entered in the National Register	no impact	Previously, two forts were built and destroyed on this same site.
Walton and Willet Stone Store	Four story limestone building	Intersection of West Seneca and Water Sts.	Entered in the National Register	no impact	Built in 1828
Musico Motors Building, originally the Wright and Boyle Sash and Blind Co.	Three story brick building	West First and West Seneca Sts.	Eligible for nomination to the National Register	no impact	This building was demolished in September, 1978

NEW YORK:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Madison Barracks	U.S. military facility characterized by several structures	Between Military Road and Black River Bay, Sackets Harbor	Entered in the National Register	possibly partially impacted	Some of the buildings are no longer standing
Sackets Harbor Battlefield	Battlefield	Coastline and area from Sackets Harbor S.W. to and including Horse Island	Entered in the National Register	possibly partially impacted	
Rock Island Light Station complex	Lighthouse and associated buildings	Rock Island, northwest of Fisher's Landing	Entered in the National Register	no impact	The present complex replaced an earlier lighthouse
Cornwall Brothers' Store	Two and a half story stone structure	2 Howell Place Alexandria Bay	Entered in the National Register	unknown	
Boldt Yacht House	Massive eclectic structure	Wellesley Island near Alexandria Bay	Entered in the National Register	possibly partially impacted	
Le Ray Stone House	Two and a half story limestone structure with several dependencies	Broadway St, Cape Vincent	Entered in the National Register	*	
Fort Haldimand	Historic archaeological district	Carleton Island, near Cape Vincent	Entered in the National Register	unknown	This district includes the fort site, midden areas, two shipwrecks, a wharf, and a cemetery
Tibbetts Point Lighthouse	Lighthouse and associated house	Tibbetts Point Cape Vincent		no impact	
Cape Vincent Fisheries Station	Stone building	Between Broadway St. and the St. Lawrence River, Cape Vincent		no impact	A house is situated on the property of the Fisheries Station

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
J-100	One and a half story stone structure	Between Route 12E and the St Lawrence River Cape Vincent		no impact	
Calumet Island Water Tower	Clapboard covered structure	Calumet Island north of Clayton		Exposed to impact	This is all that remains of the mansion formerly located on this island
Waving Branches (Ainsworth Octagonal House)	Octagon shaped, clapboard covered cottage	Route 100, village of Fine View on Wellesley Island		Exposed to impact	
Campbell House	Shingle covered structure in Victorian--Romanesque style	Between PT. Vivian Road and the St. Lawrence River Alexandria		*	
Century House		Between Route 12 and the St. Lawrence River Alexandria		*	
Cottage on Nobby Island	Clapboard covered cottage	Nobby Island, near Alexandria		no impact	This cottage has a large boathouse associated with it
Boldt Castle	Unfinished replica of a Rhineland Castle	Heart Island, near Alexandria		no impact	Several buildings and stone pillars are associated with this structure
Sunken Rock Lighthouse	Lighthouse constructed of metal	Sunken Rock Island, near Alexandria		*	
Bonniecastle	Clapboard covered structure	Bonniecastle marina off Holland St. Alexandria Bay		Exposed to impact	

NEW YORK:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
	Shingle covered structure	Ina Island, near Alexandria		no impact	
	Clapboard covered structure	Idlewild Island, near Alexandria		no impact	
Genesee Lighthouse	Octagonal limestone tower	70 Lighthouse St.	Entered in the National Register	no impact	Associated with the lighthouse is the keeper's brick house. Previously, there was a smaller stone house on this site
Dark Island Castle (Jorstad Castle)	Stone Rhine-style castle	Dark Island, near Chippewa Bay		*	This is the only complete Rhinestyle Castle remaining in the 1000 Islands
Crossover Lighthouse		Crossover Island, near Hammond		*	A boathouse and a caretaker's house are associated with this sturcture
Pine Eden	Shingle covered structure	River Road, near Morristown		no impact	
Augustus Chapman House	Stone and clapboard	Off River Road near Morristown		no impact	
Coppernall Home (White Birches)	Two story clapboard Greek Revival structure	River Road, near Morristown		no impact	
Colonel Ford House	Stone Georgian Colonial sturcture	Off River Road near Morristown		no impact	
Brick Block	Brick structure	St. Lawrence Av., Waddington		no impact	
Tomlinson House	Two story stone structure	St. Lawrence Av., Waddington		no impcat	
Ogden Land Office					

NEW YORK:continued

SITE #	DESCRIPTION	GENERAL LOCATION HARBOR	INVENTORY STATUS	POTENTIAL IMPACT	COMMENTS
Ogden Land Office	Stone structure	Oak St. and St. Lawrence Av. Waddington		no impact	
U.S. Customs House (Parish Store)	Three story plus dormered attic stone structure	127 North Water St., Ogdenburg	Entered in the National Register	no impact	
Fort Levis	Historic archaeological site	Chimney Island near Ogdensburg	Eligible for nomination	unknown	Chimney Island was referred to as Isle Royale by the early French
Robinson Bay Archaeological Conservation Area	This area consists of six archaeological sites	Robinson Bay, Massena	Entered in the National Register	unknown	Cultural affiliations are Late Archaic, Middle Woodland, and Historic

* Out Buildings or Improvements of Historic/Cultural Significance Exposed to Impact (Palm 1977).

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Shipwrecks

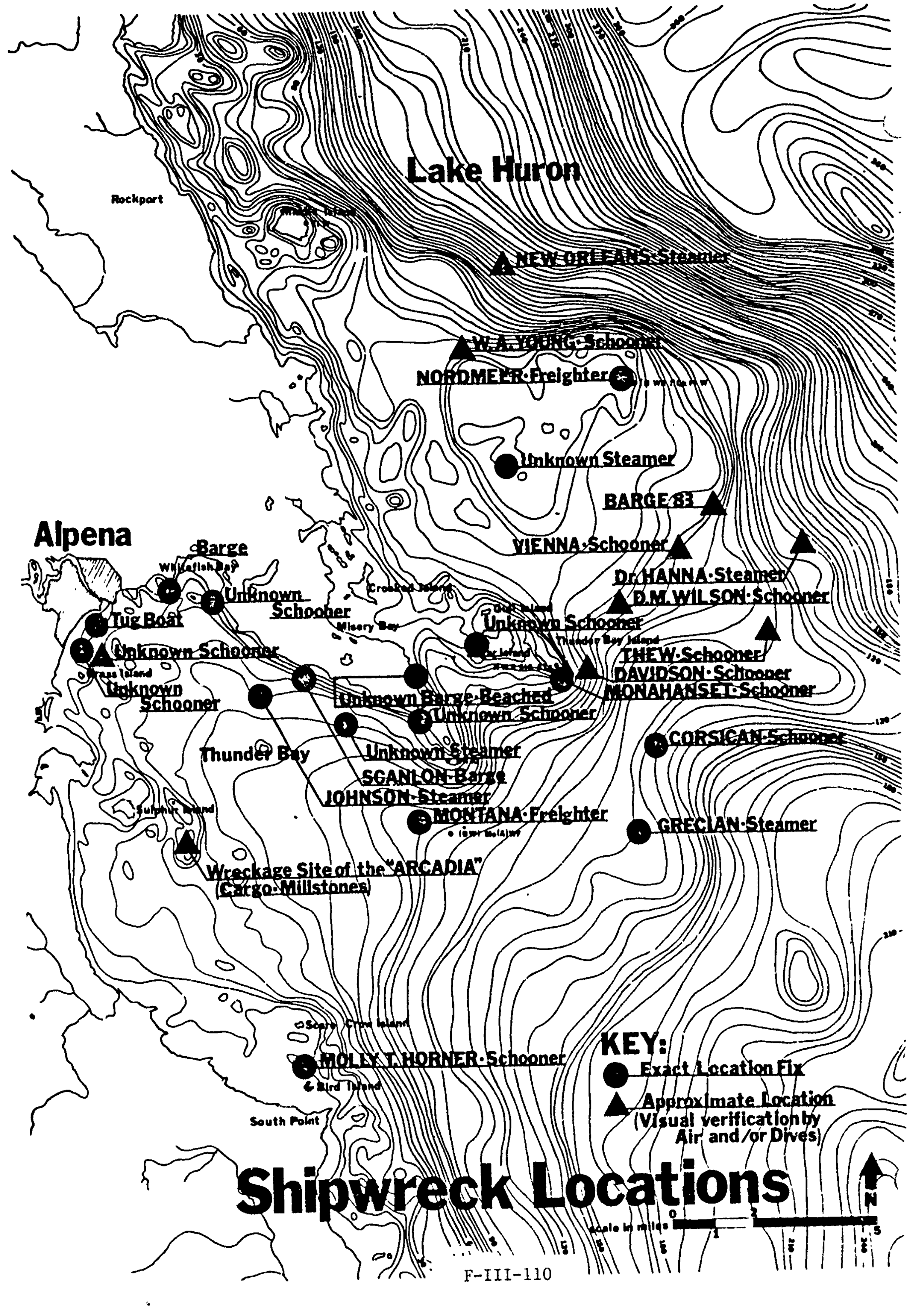
Although thousands of vessels are known to have been lost on the Great Lakes since the GRIFFON in 1679, there have been very few efforts to systematically locate and evaluate the wrecks. As the attached bibliography indicates, there have been many brochures and publications prepared on the subject of shipwrecks on the Great Lakes. Heden (1966), Frederickson and Frederickson (1959, 1961 and 1963) are popularized listings and stories of wrecks. The Midwest Explorers League has published wreck location maps which show hundreds of ships for sport divers to enjoy. Despite the look of authenticity (they are printed on facsimile NOAA charts), the locations are generally much too vague for reliable relocation. In addition, the maps were basically assembled from records without on site confirmation of the existence or condition of the wreck.

The historical evidence of shipping on the Great Lakes lies beneath and adjacent to the channels, rivers, and harbors of this study. The existence of these wrecks is well known, but only rarely have the exact locations and conditions of vessels been determined. Some are within the designated harbors, others are adjacent to the channels or sunk in the rivers. Those which were navigation hazards have been removed. At present, it is not possible to know if material from dredging would be placed over a wreck because so little is known of locations. It is not possible to say if a wreck lying in 50 feet of water under vessel routes is less impacted by propeller wash than one lying in 12 feet of water, away from a channel but vulnerable to ice scouring generated by ship passage. A series of parameters could be set which realistically limits the scope of reasonable impact tolerances. (For example, locations within a mile of the harbor entrance or within a harbor where water depth is less than 50 feet). Using these parameters, the harbors, channels, rivers, and shipping lanes of shallow depth could be intensively surveyed using various electronic exploration equipment ranging from recording fathometers to magnetometers. Brief dives could be made to confirm

and identify results. At this stage, the identity of the vessels recorded may or may not be possible, but a careful description of the wreck could narrow the probabilities considerably. Upon completion of this task for harbors, channels, waterways, shipping lanes, and rivers, more intensive studies could be undertaken with a "known universe" to sample for purposes of historic preservation and/or modifications of existing navigation patterns, as needed to mitigate impacts generated by the extended navigation season activity. Construction sites, disposal site locations, and dredging activities could then avoid such areas.

The coastal waters of Michigan contain well over 1300 wrecks (Wright n.d.:5) with lengths of over 45 feet. From Port Huron to the southern boundary of Presque Isle County, there are 265 recorded lost vessels, while the area of the Straits of Macinac have 146 recorded losses (Wright n.d.:5). The Center for Archival Collections at Bowling Green State University has data on over 6000 Great Lakes and connecting waterway wrecks. This archive would be a primary resource for any shipwreck investigation.

However, there have been only two systematic attempts to locate underwater cultural resources and visually verify their existence and condition. These are contained in the Duluth-Superior Harbor Cultural Resources Study (Walker and Hall 1976) and The Thunder Bay Shipwreck Survey Study Report (Warner and Holecek 1976) covering the Alpena area of Michigan. The former noted no wrecks in the Duluth-Superior Harbor, but located several within a very short distance of the Duluth Harbor entrance. In addition, that report noted the existence of remnants of the old Duluth Harbor submerged northeast of the present harbor. The Thunder Bay report listed 17 wrecks examined by divers and nine wrecks identified but not visited by divers. The same report notes that Wright has information on 57 more wrecks believed to lie in Thunder Bay. A copy of the location map from that report is attached.


Lake Huron
Rockport
Alpena
NEW ORLEANS·Steamer
W.A.YOUNG·Schooner
NORDMEER·Freighter
Unknown Steamer
BARGE 83
VIENNA·Schooner
Dr. HANNA·Steamer
D.M.WILSON·Schooner
Barge
Unknown Schooner
Tug Boat
Unknown Schooner
Unknown Schooner
Crooked Island
Misery Bay
Unknown Schooner
THEW·Schooner
DAVIDSON·Schooner
MONAHANSET·Schooner
Unknown Barge·Beached
Unknown Schooner
CORSICAN·Schooner
Thunder Bay
Unknown Steamer
SCANLON·Barge
JOHNSON·Steamer
MONTANA·Freighter
GRECIAN·Steamer
Sulphur Island
Wreckage Site of the "ARCADIA"
(Cargo·Millstones)
Scare Crow Island
MOLLY T. HORNER·Schooner
Bird Island
South Point
KEY:
Exact Location Fix
Approximate Location
(Visual verification by
Air and/or Dives)
Shipwreck Locations
N
scale in miles
0
1
2
5

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Recommendations

The recommendations which can be generated with the data in hand are general where the specific setting of each site and specific project activities are speculative. In certain instances data exist which make it possible to predict "no impact". But the prevalence of incomplete information makes it necessary to recommend a posture of continuing investigations throughout the design and construction phases of the project on a case by case basis.

The critical information needed to be able to assess impacts is of two kinds. The first is very specific site location data, available only by means of extensive and intensive on-site surveys for historic and prehistoric archaeological sites, historic structures, shipwrecks, and paleontological sites, historic structures, shipwrecks, and paleontological sites. These would incorporate impact assessments from the vantage point of a detailed familiarity with the exact setting of the cultural resource. The second kind of information needed is a detailed description of the potential impacts themselves. This includes technical, temporal and special information.

As a result of the above considerations, recommendations are of two kinds. The first is to conduct the needed surveys for archaeological sites, historic structures, shipwrecks, and paleontological sites in the harbor areas, connecting channels, and rivers, islands and the St. Lawrence Seaway. The exceptions to this recommendation are listed below in the state by state considerations. These are supported by positive indications that potential impacts could be significant and could be avoided. The second major recommendation is that a series of actual impact situations be monitored in order to identify effects which could be minimized or eliminated. This would greatly facilitate the process of assessment.

Recommendations By State

Minnesota

To date, no systematic archaeological or historic structure surveys have been conducted for Silver Bay, Two Harbors, or Taconite Bay. The recommendation of this study is that historic structure and archaeological surveys be developed for the three harbors in relation to specific project effects, identified during post-authorization design and construction stages of the project. In addition to these surveys, an assessment of the impact of the extended navigation system on wrecks within these harbors and along the approaches to them should be further identified and evaluated.

Although the Duluth-Superior study is extensive and quite detailed, additional information would be required to assess the impact of the extended navigation system on the following: (1) the historical significance of the Old Duluth Harbor Ruins east of Third Street; A diving operation could be designed to assess the importance of these ruins; (2) the wreck of the Whaleback Steamer THOMAS WILSON which lies east of the Duluth canal should be addressed; and finally, (3) shipwrecks within 50 feet of the shipping lanes which approach Duluth Harbor.

Wisconsin

Duluth-Superior Harbor - This harbor ices over completely in the winter. The selected plan for the Navigation Season Extension (Vol. I, Final Report, Great Lakes Navigation Season Extension Harbor Study) consists of the use of icebreaking tugs operating in a continuous cycle within the harbor basin, passing through each area at least once a day and the use of bubblers along some dock facilities. Potential impacts could potentially result from ice movement and increased vibration of ship passage. A monitoring of known historic structures faced with possible impact should be undertaken to assess the significance of the structures in terms

of the NRHP. An on-site inspection of the referenced archaeological sites followed by further evaluation in terms of the NRHP could be conducted.

Ashland Harbor - A high power icebreaking tug to be used only when shipping is scheduled in the port and a single bubbler at the only active dock within the harbor are components of the selected plan for extending the navigation season. This activity could create potential impacts from the ice movements and vibrations from ship passage. Effects on shorelines and shore structures should be identified.

An on site survey of historic and prehistoric archaeological sites from the literature followed by evaluation of site significance could then be accomplished. In addition, the outer islands, both in Bayfield Co. and Ashland Co. which are located within one mile of the shipping lanes, could also be evaluated for project effects and then for historic and prehistoric cultural resource effects, as required. The Federal Register lists as many as twelve historic structures and two archaeological sites close to the shorelines of these areas are already on the NRHP.

Green Bay Harbor - Green Bay Harbor frequently becomes ice bound in the winter. The selected plan for extended navigation consists of use of a medium powered icebreaking tug to keep navigation channels open which could impact the shoreline through ice movement and increased vibration. Historic structures already identified through survey and located within the potential impact zone should be monitored to identify significant effects in terms of the NRHP. An on site inspection and evaluation of archaeological sites within the impact area should also be accomplished. In addition, the bay shoreline and islands of the Door Co. peninsula located within one mile of the shipping lanes should be included in this study. A historic district and five historic properties adjacent to shorelines and thus potentially exposed to impact are listed in the NRHP for this

area. Sturgeon Harbor, home port of one of the icebreaking tugs should also be included in the study.

Port Washington Harbor - Due to thermal discharge from a large power plant and a favorable location on the windward side of the lake, this harbor does not ice up in the winter. No special measures need be taken since the port is already operating as a year round harbor. Port Washington is an artificially constructed facility. The single known archaeological site recorded near the impact zone has remained unaffected. This port has functioned on a year-round basis for a number of years and extended navigation would create no additional adverse effects. Minimally, the historic structures already located within the impact zone should be evaluated in terms of the NRHP and an assessment of any secondary effects of increased harbor traffic on the structures made.

Milwaukee Harbor - This harbor is considered a year-round facility and usually remains ice free or only experiences minor ice cover during severe winters. Since this port has functioned on a year-round basis extended navigation would create no additional adverse effects. The Federal Register shows at least seven historic structures are on or near the Milwaukee River within the upstream limit of the project. Also, a historic district is situated between the harbor and the Milwaukee River. This historic structure survey already completed for Milwaukee should be monitored in terms of any additional NRHP eligible structures. On site inspection would be conducted to determine the effects on archaeological sites by increased vessel passage.

Illinois

The two harbors of Illinois have no need for further consideration of archaeological sites. Chicago Harbor is built on fill and contains no archaeological sites, and Calumet Harbor is so impacted by previous

construction that it has been written off by the archaeologist of the Illinois SHPO. The Chicago historic structure survey was deemed adequate by the SHPO staff historian; however, impact assessment of identified properties should be accomplished. The Calumet Harbor needs a historic structures survey and both harbors need shipwreck surveys. No paleontological sites are likely to occur in either harbor area.

Indiana

The four harbors in Indiana as well as the Illinois/Indiana Calumet Harbor should be subjected to systematic historic structure surveys and shipwreck surveys. Archaeological and paleontological surveys of the heavily impacted harbor shorelines would not be likely to produce significant information.

Michigan

There is a need to complete surveys locating and evaluating cultural resources in the harbors and connecting waterways with respect to their eligibility for placement on the National Register of Historic Places. This would include surveys for archaeological sites, both prehistoric and historic in nature, comprehensive historic structures surveys, paleontological surveys and surveys to determine presence and impact on shipwrecks in harbor areas affected by activities related to extended winter navigation. Areas have been identified which are exempt from one or more of the above stated considerations.

There is no need for a survey of prehistoric archaeological sites in the Detroit Harbor area. Filling along the Detroit waterfront has built the present river bank east of where it was in prehistoric times. Historic sites could be identified systematically. In other harbor areas the specific nature of the shorelines and potential for archaeological sites (prehistoric and historic) remain unknown.

Systematic shipwreck surveys, such as in Thunder Bay, would be valuable for each of the harbors.

Intensive historic structure surveys of the harbors, connecting channels and rivers, island shorelines, as well as the shipwreck surveys should continue throughout development of stages of the project.

Ohio

As the shallowest of the Great Lakes, Lake Erie has a compound problem concerning ice related impacts. The lake freezes over with complete ice cover for periods of greater relative duration than the other lakes. In addition, all of the Ohio harbors are exposed to northwesterly winds and ice flow jams which could cause blockage at the harbor entrances. All of the harbors have an average depth of less than 30 feet and dredging is necessary to maintain the navigation access channels to the harbor ports.

In all harbors, with the exception of Cleveland Harbor, whose thermal effluents prevent freezing in the harbor, icebreaking would be necessary to extend the navigation season.

Cultural resources, in the form of archaeological sites, historic sites, and underwater wreck sites are known for each Ohio Harbor except Huron Harbor. Huron Harbor has no recorded archaeological or historic cultural resources.

Surveys and documentation of archaeological sites should be continued throughout design and construction stages of the project, including field surveys for each harbor and lake shore area where shipping lanes pass within one mile of shore. Catawba Island Point, Kelley's Island, the South Bass Island Group and shorelines adjacent to harbor entrances should be surveyed for archaeological sites

where their shore could be impacted. Areas already totally impacted by intensive industrial development such as Cleveland Harbor and areas constructed by land fill or covered by dredged material would be excluded.

Systematic survey and recording of historic structures are incomplete for all of the Ohio harbors. In the harbors where numerous historic sites have been identified, monitoring of the structures in the terms of possible impacts from navigation season extension activities would be advisable. Surveys and evaluation of historic structures according to their potential eligibility for nomination to the National Register of Historic Places are recommended for each harbor impact area.

Cultural Resources in the form of underwater wrecks are a major concern for Lake Erie because of the extreme shallowness of the lake. Records for underwater shipwrecks exist for each Ohio harbor area. Further identification of shipwreck locations is recommended for each Ohio harbor, in areas which could be impacted by activities associated with navigation season extension. Any additional dredge disposal or land dump area could be surveyed for archaeological and/or historical cultural resources. Construction of any new harbor improvements for the navigation season extension, such as special cargo facilities, docking areas, turning basins, and disposal areas, would be surveyed for cultural resources.

As a result of the literature and records search for the Ohio harbors concerned in the Great Lakes Navigation Season Extension Study the potential for significant cultural resources being located within the impact areas as well as the incompleteness of existing documentation has been identified. Huron Harbor has no recorded archaeological or historical sites. A continuation of these surveys is recommended through design and construction phases of the Program, including field surveys in order to identify and obtain specific locations of archaeological, historic, and underwater cultural resources for each Ohio harbor.

Pennsylvania

Erie Harbor has never been the focal point of a systematic reconnaissance for archaeological sites, standing structures, or shipwrecks. The literature is indicative of the area's rich cultural heritage, but a comprehensive cultural resources planning document is lacking for the harbor.

Specifically, French Port Presque Isle and British Fort Presque Isle, both located near the mouth of Mill Creek, Perry's Shipyard, located at the mouth of Cascade Creek, and Perry's Shipyard #2, located at the mouth of Garrison Run, are known sites, but nothing is known of their integrity. These sites are all located on the southern edge, or the most developed portion of Erie Harbor.

The area of the harbor exhibiting the least development, Presque Isle, is also archaeologically unknown but an archaeological reconnaissance of this area will be conducted during the summer of 1979 by Gannon College.

The dredging operations in portions of the harbor have probably destroyed some of the shipwrecks, but due to the long history of the harbor, other shipwrecks may remain. Two ships are known to have been recovered from Misery Bay. No systematic reconnaissance of the harbor bottom has been accomplished.

Finally, no comprehensive survey of historic structures has been conducted in the immediate vicinity of Erie Harbor. Several structures have been identified in the literature, but based upon the long history of the harbor and the lack of a systematic survey, there could be other structures having historic significance.

New York

The Buffalo, Rochester, and Oswego Harbors, and the islands in the St. Lawrence River belonging to the United States and the land adjacent to the St. Lawrence River in Jefferson and St. Lawrence Counties, New York, have never been, with one exception, the subject of a systematic reconnaissance for archaeological sites, standing structures, or shipwrecks. One exception is the historic structure survey (Palm 1977) conducted for the islands in the St. Lawrence River and the land adjacent to the river in Jefferson and St. Lawrence Counties, New York. However, this did not include archaeological sites or shipwrecks.

Because of limited available information it is recommended that the Buffalo Harbor should have additional investigations made of historical/cultural resources in the post authorization phase. Additional information on shipwrecks could be obtained in the shipping lane(s) leading to the harbor. An area on either side of the shipping lane(s) is recommended for investigation. The Lackawanna Canal, the Union Canal, the Buffalo River Channel, and the Black Rock Canal Entrance Channel are here considered as ports of the Buffalo Harbor.

The Oswego Harbor presents limited problems for year-round navigation. The proposed alterations are confined to the harbor entrance channel. Therefore, the only recommendation for this harbor is to investigate a corridor on either side of the shipping lane(s) leading to the harbor for shipwrecks.

In 1978 an Environmental Assessment of the FY 1979 Winter Navigation Demonstration on the St. Lawrence River was made by the New York Department of Environmental Conservation. Cultural resource studies were conducted by the St. Lawrence-Eastern Ontario Commission for a 20-mile long Demonstration Corridor and in adjacent shoreline segments upstream and downstream on the St. Lawrence River. The purpose of these studies was to determine what, if any, impact on

these resources can be expected from the Winter Navigation Demonstration. Data were drawn largely from Commission files, with additional data provided by field survey.

For purposes of this study, the Demonstration Corridor extends from a point just downstream from Holmes Point in the Town or Morristown to a point on Sparrowhawk Point, opposite Cardinal, Ontario and includes the Town of Oswegatchie and parts of the Town of Morristown and the City of Ogdensburg.

The analyses provided in this report include a description of historic sites and other social amenities in the area and a discussion of the possible impacts of the Winter Navigation Demonstration Program on these. This report also examines land use plans (both existing and proposed) and attempts to determine how these plans may be impacted by the Winter Navigation Demonstration.

Along the Demonstration Corridor itself, there were only two identified historic sites on the water. They are the Customs House in the City of Ogdensburg on the north side of the mouth of the Oswegatchie River, and the Ford House on Chapman Point in the Village of Morristown.

Historic sites were also inventoried for 10 miles on either side of the Demonstration Corridor. In the first 10 miles upstream of the Demonstration Corridor there are four historic sites whose properties touch the river. These are the Coppernall House (White Birches), a clapboard house approximately a mile south of the Village of Morristown on Holmes Point; "Pine Eden", a shingled house in the Town of Morristown just south of Jacques Cartier State Park; the Chapman House, a stone house just north of Point Comfort in the Town of Morristown; and the Crossover Lighthouse, an inactive metal lighthouse structure on Crossover Island in the Town of Hammond.

In the first 20 miles downstream of the Corridor, there are three

sites near the river, all in the Village of Waddington: the Ogden Land Office; the "Brick Block" of houses; and the Tomlinson House. However, these sites are all removed from the river by a narrow strip of land owned by the Power Authority of the State of New York (PASNY) and used as a park. Field survey indicated all sites were 0.32 to 18.0 feet in elevation above water level.

Several public recreational facilities, and numerous commercial recreational facilities, are located along the Demonstration Corridor and adjacent shoreline sections, but no impacts were anticipated from the Demonstration. Of greater concern are the 622 individual shoreline structures (docks and boathouses) in the corridor. An additional 187 shoreline structures are present in the upstream 10-mile segment, and 15 more occur along the downstream segment. Nine of these structures occur in areas subject to possible impacts from ice forces which could be caused by the Demonstration. Since all of these structures are on the shoreline, additional impacts should be anticipated if water level increases occur.

Over 28 percent of all ice fishing along that portion of the St. Lawrence River from Chippewa Bay to Coles Creek occurs in the Demonstration Corridor, particularly at the Port of Ogdensburg. Disruption of these activities, including ice fishing derbies scheduled in the Corridor could occur from Demonstration ship passages.

Some 10 miles of the shoreline of the Demonstration Corridor have been classified in the medium to very high shoreline erodibility category. Changes in water levels and increased erosion could impact the planned use of these areas, particularly at Galop Island. Mitigating measures should be developed for these and other potential impacts.

Impacts that affect historic sites are most likely to occur from changes in water levels and changes in exposure to ice forces. Changes in water levels that decrease the level in the Demonstration Corridor

are hypothesized to have no impact on historic structures. This is based on the fact that none of the sites would normally be used for open water recreation activities during the Demonstration Corridor could result in limited negative impact. One structure would be impacted if the water level increased by .32 feet; two additional ones if water levels increased by 2 to 3 feet. All other structures are over 5 feet above the normal maximum water level.

Changes in exposure to ice forces that are likely to impact the historic sites could arise either from the location of the ice being influenced by water level changes or by ice forces created by activities related to demonstration ship passages, such as ice breaking and transit of ships subsequent to ice formation. The analysis relative to water level changes applies to ice forces as well. Increases in water levels could result in limited negative impacts while decreases could have limited positive impact.

Impacts from ice forces created by activities related to the Demonstration could have a negative impact on the boathouse on Crossover Island near Hammond, N.Y. This structure is associated with the historic lighthouse on that island. The boathouse is only .32 feet above water level and is located in an area identified as having "high" potential for impact from ice forces created by winter navigation. Further study of this site would be required in post authorization efforts. None of the other historic structures are in areas classed as having potential for impact; thus the impact they would experience would most likely be only that caused by changes in water levels as they affect ice.

Illinois Department of Conservation
life and land together

605 WM. G. STRATTON BUILDING • 400 SOUTH SPRING STREET • SPRINGFIELD 62706
CHICAGO OFFICE - ROOM 100 160 NO. LASALLE 60601
David Kenney Director • James C. Helfrich Assistant Director

November 19, 1979

Mr. P. McCallister
Chief, Engineering Division
Department of the Army
Detroit District
Corps of Engineers
Box 1027
Detroit, Michigan 48231

Dear Mr. McCallister:

We have reviewed your inventory of Illinois cultural resources as included in "Cultural Resources, Records and Literature Search of Areas Potentially Impacted by the Great Lakes - St. Lawrence Seaway Navigation Season Extension."

I would like to inform you of several changes in the status of resources discussed: [1]

Chicago Harbor Lifeboat Station	included in Illinois Historic Sites Survey
Navy Pier	on National Register 9/13/79
BVR 661	National Register - pending

I would also like to inform you that the repository of the Illinois Cultural Resources Inventory is located within the Historic Sites Division of this department. [2]

Sincerely,

David Kenney

David Kenney
State Historic
Preservation Officer

DK/AEM/js

1. Thank you. These changes have been added to the report, Appendix F, Section III.

2. This is now noted in the report, Appendix F, Sec.III.

MICHIGAN DEPARTMENT OF STATE
RICHARD H AUSTIN SECRETARY OF STATE

LANSING
MICHIGAN 48918

MICHIGAN HISTORY DIVISION
ADMINISTRATION, ARCHIVES, HISTORIC SITES, AND PUBLICATIONS
3423 N Logan Street
517-373-0510
STATE MUSEUM
505 N Washington Avenue
517-373-0515

November 21, 1979

P. McCallister
Chief, Engineering Division
Department of the Army
Attention: Environmental Resources Branch
Detroit District Corps of Engineers
Box 1027
Detroit, Michigan 48231

Re: ER 1839 (MHD)
DACW 35-79-M-0460
(SSI) ESI-1415

Dear Mr. McCallister:

Our staff has reviewed the "Cultural Resources Records and Literature Search of Areas Potentially Impacted by the Great Lakes-St. Lawrence Seaway Navigation Season Extension," and have the following comments:

We have no real comments of any substance to make, other than to note that SSI did a very poor job of proof-reading, leading to a major typographical error on page 13, incorrectly identifying the State Historical Society of Wisconsin as the Wisconsin Historical Society, and misspelling Kathryn Eckert's name. The bibliography for the Michigan section is littered with typographical errors and incomplete references (cf. Michigan's section with all the other state sections). This should not be allowed to pass in its current form. Fortunately the recommendations are reasonable and accurately reflect the situation in our state. | 1

If you have further questions, please contact Donald E. Weston, Environmental Review Coordinator for the Michigan History Division, at 517/373-3703. Thank you for giving us the opportunity to comment.

Sincerely,

Martha M. Bigelow
Director, Michigan History Division
and
State Historic Preservation Officer

BY: Michael J. Washo
Deputy State Historic Preservation Officer

MJW/DEW/pr

1. These changes have been made as noted (Appendix F, Section III).

Ohio Historic Preservation Office
Ohio Historical Center I-71 & 17th Avenue Columbus, Ohio 43211 (614) 466-1500

November 16, 1979

Mr. P. McCallister, Chief
Engineering Division
Department of the Army
Detroit District Corps of Engineers
P. O. Box 1027
Detroit, Michigan 48231

Re: Great Lakes-St. Lawrence Seaway
Navigation Season Extension

Dear Mr. McCallister:

This is in response to your letter of November 8, 1979, requesting our comments on the "Cultural Resources, Records and Literature Search of Areas Potentially Impacted by the Great Lakes-St. Lawrence Seaway Navigation Season Extension" which is to be included in the Environmental Impact Statement for the above project.

The staff of the Ohio Historic Preservation Office has reviewed the report with regard to the impact of the project on cultural resources. It appears from the present data that there are at least 82 identified resources within the project area and 23 of these are eligible for, nominated to or listed in the National Register of Historic Places. The latter could possibly be affected by activites associated with the extension of the navigation season, particularly disturbances caused by ice floes. However, the inventory of cultural resources has not yet been completed for Ohio, and existing documentation is inadequate to make determinations of effect for all the harbor areas along the Ohio shore of Lake Erie. 1

Our office concurs with the recommendations of the report that a systematic field survey is needed to locate and identify archaeological, historic and underwater resources. This documentation and a determination of the effect of the project upon these resources should be included in the final Environmental Impact Statement. 2

Thank you for the opportunity to review and comment on this project. The report will be kept in our files for future research.

Sincerely,

David L. Brook

David L. Brook
State Historic Preservation Officer

DLB:LS:djd

1. This information has been added to the report, Appendix F, Sec. III.

2. This has been noted in the FEIS and appropriations recommended for implementation.

NEW YORK STATE PARKS & RECREATION Agency Building 1 Empire State Plaza Albany New York 12238 Information 518 474-0456
Orin Lehman Commissioner

October 26, 1979

Mr. Robert V. Vermillion
Colonel, Corps of Engineers
District Engineer
Dept. of the Army
Detroit District, Corps of Engineers
Box 1027
Detroit, Michigan 48231

Attention: NCEED-ER

Dear Mr. Vermillion:

Volume III, FES
Interim Feasibility Study
September, 1977
Great Lakes - St. Lawrence Seaway
Navigation Season Extension
Multiple County

The State Historic Preservation Officer (SHPO) has reviewed the document referenced above, which we thank you for submitting to us.

We are concerned that extensive ice build-up could pose a hazard to cultural resources that are included in or may be included in the National Register of Historic Places. One area that we are concerned about in particular is Carleton Island. Both the remains of Fort Haldimand as well as a shipwreck located in North Bay are currently included in the National Register of Historic Places. We solicit the comments of your agency concerning the effects of such ice build-ups upon cultural resources. 1

If you should have any questions, please contact the project review staff at 518-474-3176.

Sincerely,

STATE HISTORIC PRESERVATION OFFICER

By Stephen J. Raiche, Director
Historic Preservation Field Services

LRK:mr

cc: Advisory Council

1. Ice build up is not anticipated in the proximity of Carleton Island as a result of maintaining the navigation channel for extended winter navigation. The navigation channel is 50 to 100 feet deep in this stretch of the St. Lawrence River, with approximately one-half mile of deep water between the navigation channel and North Bay. The configuration of the river bottom in this area shows two drop-offs beyond the shallow offshore shelf. These physical features substantially protect the shoreline area from ice breaking activities in the channel. The depth of the river should provide protection for shipwrecks beyond the shallow near shore zones. However, further investigations of the effects of extending winter navigation would be conducted should Congressional approval of the project be obtained and upon consequent development of more detailed, site-specific planning and design.

United States Department of the Interior

HERITAGE CONSERVATION AND RECREATION SERVICE
LAKE CENTRAL REGION
ANN ARBOR MICHIGAN 4810?

IN REPLY REFER TO:
1201-04

November 21, 1979

Mr. P. McCallister
Chief, Engineering Division
Attention: Dr. Marian Cooper
Department of the Army
Detroit District, Corps of Engineers
Box 1027
Detroit, Michigan 48231

Dear Mr. McCallister:

This is in responsse to your November 8 request for our review of the report entitled "Cultural Resources, Records and Literature Search of Areas Potentially Impacted by the Great Lakes-St. Lawrence Seaway Navigation Season Extension."

We have reviewed the cultural resources report and find it adequate as a preliminary document. As indicated, further work will be necessary to assess the impacts of the project on the resources and to develop satisfactory mitigation measures. Once the project is more specifically outlined, we suggest that resources not currently listed in the National Register be considered for their eligibility. On-site archeological surveys should be conducted for this same reason. With this information, it will be possible to complete the state charts regarding impacts the project will have on archeological and historic resources. | 1

Finally, we suggest that the Corps remain in contact with the State Historic Preservation Officer in the various States to see that this work is properly completed. | 2

Sincerely,

Robert L. Pierce

Robert L. Pierce, Chief
Division of Planning Assistance

1. Funding has been recommended for site-specific archeological studies should Congress authorize the project.

2. Continued coordination will be carried out.

HISTORIC PRESERVATION DIVISION

December 4, 1979

Mr. P. McCallister
Chief, Engineering Division
Detroit District, Corps of Engineers
Box 1027
Detroit, Michigan 48231

SHSW: 0541-79
RE: NCEED-ER Navigation Season Extension

Dear Mr. McCallister:

Thank you for the opportunity to comment on the cultural resources literature search that was prepared by Soils Systems, Inc., for this project.

In general we feel that this report accurately reflects the status of our knowledge concerning cultural resources in Wisconsin and that the scope of work was adequate at this stage of project development. We concur with the recommendations made in the report.

One recommendation contained in the consultants report was omitted from your draft conclusions. This concerns the need to survey, research and identify properties on the mainland that may be eligible for inclusion on the National Register of Historic Places. It appears to us that this recommendation was inadvertently omitted from part 5.128 as the beginning line of 5.129 seems to refer to a previous recommendation. 1

1. Necessary surveys for archaeological sites, historic structures, shipwrecks and paleontological sites in and around Wisconsin harbor areas, rivers and islands (including any other areas that could be influenced by Navigation Season Extension Program activities), would be conducted as required.

If we can provide you with any further information on historic and archeological sites in Wisconsin, please contact me at (608)262-2732. We look forward to receiving the Draft Environmental Impact Statement.

Sincerely,

Richard W. Dexter
Compliance Coordinator

RWD:dk

THE STATE HISTORICAL SOCIETY OF WISCONSIN

SECTION F-IV

ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED ACTIVITIES BE IMPLEMENTED

Oil Or Hazardous Material Spills

Although the Great Lakes have never experienced a catastrophic winter-related oil spill and no vessel related spills of significance have occurred during winter operations, the risk of an oil or hazardous material spill on the Great Lakes due to vessel operations, land facilities, or pipelines is still real. Pollution incidents in and around U.S. waters for the calendar year 1976 have been compiled by the U.S.C.G. Of the 12,655 incidents recorded around or in U.S. waters, 973 (7.7%) incidents occurred on the Great Lakes and accounted for 25.9% of the total volume (33,851,830 gallons) of the oil and hazardous substances pollution incidents. Of the total volume of oil and hazardous substances spills recorded around or in U.S. waters, 14.7% was crude oil; 28.9% fuel oil; 2.3% gasoline; 1.4% other distillate fuel oil; 0.3% solvent; 3.2% diesel oil; 14.7% asphalt or residual fuel oil; 0.3% animal or vegetable oil; 0.4% waste oil; 2.1% other oils; 6.2% liquid chemicals; and 19.1% other pollutants (sewage, dredge spoil, chemical wastes, etc.).

Of the 12,655 national incidents 3,296 (26.0%) were from vessels; 3,121 (24.6%) non-transportation-related facilities; 653 (5.2%) pipelines; 560 (4.4%) marine facilities; 464 (3.6%) land vehicles; 182 (1.4%) land facilities; and 4,379 (34.6%) misc./unknown causes.

Of the 1973 incidents that occurred on the Great Lakes: 85 incidents (15,014 gallons) occurred in open international waters of the Great Lakes; 488 incidents (6,382,696 gallons) occurred in rivers/channels; 142 incidents (2,114,632 gallons) occurrred in ports or harbors; and 258 incidents (244,725 gallons) occurred on beaches or non-navigable waters.

Causes of 12,655 oil and hazardous substances pollution incidents consisted of: hull/tank rupture/leak 6.2%; transportation pipeline rupture/leak 3.2%; other structural failure 3.2%; pipe rupture/leak 6.9%; railroad/highway/aircraft accidents 2.0%; valve failure 3.2%; pump failure 1.2%; other rupture leak 2.7%; other equipment failure 8.1%; tank overflow 8.5%; improper handling operation 3.9%; other personnel error 4.2%; bilge pumping 1.9%; ballast pumping 0.3%; other intentional discharge 1.8%; natural or chronic phenomenon 2.5%; and unknown causes 39.2%.

Of the 12,655 pollution incidents recorded naturally, 7.9% occurred in January; 7.8% February; 9.0% March; 9.3% April; 8.7% May; 9.3% June; 9.6% July; 9.1% August; 8.5% September; 7.4% October; 6.4% November; and 7.1% occurred in December.

As stated above, the risks of an oil/hazardous materials spill are real. This risk is unavoidable since the risks of contaminants under winter navigation or normal navigation can never be reduced to zero. It is for this reason and the concerns of uninformed persons that the discussion of oil spillage and how it could be handled, if it should occurr in an ice and water environment, is warranted.

Probability of an Oil Spill in an Extended Navigation Season

Hazards of navigation in a complete ice environment could decrease the potential for an oil spill because of the following:

a. Vessels traveling through ice are normally not able to move at high rates of speed.

b. Vessels are not able to move out of their tracks with ease. When they do start to move out of the vessel track, it is relatively easy to stop them because of the friction of the ice.

c. There are not many vessels operating, and these generally operate with an escort when they are in difficult waters.

d. The effects of wind and waves are considerably reduced with lake waters covered or largely covered by ice.

e. Ice along shorelines, breakwalls and other obstructions tend to serve as a buffer to keep the vessels away from danger and each other. An example of this was the grounding of the tanker at Traverse Bay (1977). Because the vessel was in ice and moving slowly, she went aground so gently the master didn't even realize she was aground. Once there, she was held off the beach and away from the rocks by fast ice along the shore, thus, in this case, preventing any major damage from being done to the vessel.

f. In recent years the Coast Guard has gone to some considerable length to request and advise operators of vessels that are ill equipped (not reinforced, not "doubled skinned" or designed for ice operations and which do not have a horsepower-to-length ratio greater than 6 to 1) to refrain from operations in late winter and early spring. The Coast Guard is realizing increased success with this request and is receiving a considerable degree of cooperation from the shipping industry.

Determination of an accurate statistical probability of an oil spill occurring on navigable waters is dependent on many variables. The probability of these variables occurring is not completely known. Examples of these variables include, but are not limited to, weather conditions, ship structure, ship personnel, the number of vessels operating, volume and type of cargo, natural hazards of a body of water, etc. Yet, some estimates have been made for the open sea in which the chance of a cargo oil spill have been speculated at 1 in 1,000 for the volume transported.

Another study "Ice Conditions and Proposed Containment and Removal of Spilled Oil on the St. Clair and Detroit Rivers" has estimated that the probability of an oil spill occurring in St. Clair and Detroit Rivers could be twice that of the open sea.

The above estimate was based in part on these assumptions:

a. The probability of a spill occurring in the Great Lakes is equal to that occurring in the open sea.

b. Navigation channels are confined and ice hinders the maneuvering of the ships. Therefore, the chance of an oil spill would be increased.

c. The probability of an oil spill could be due to ill equipped vessels.

These last assumptions may exaggerate the true probability of an oil spill occurring in the Great Lakes.

A second approach in estimating the probability of an oil spill would be to determine the actual spill frequency. The Environmental Protection Agency has stated that "approximately 1 barrel of product is lost for each one million transported." This figure differs greatly from that which was estimated at 1 to 1,000 of volume transported. A difference of 999,000 for volume transported exist between the estimated and actual occurrence of oil spills.

It would, therefore, appear that the true probability of an oil spill occurring would lie between the estimated and the actual occurrence.

In conclusion, the probability of an oil spill in the Great Lakes and connecting channels does exist and its potential to occur could increase or decrease with the extension of the navigation season. The St. Clair and Detroit Rivers study has stated that the probability of an oil spill in

the presence of ice is higher for the spring break-up than for the winter freeze-up period, and spring break-up usually occurs during the normal navigation season.

Oil Pollution Problems Associated with the Extended Navigation Season

One of the risks associated with the extension of the Great Lakes navigation season is the possibly increased potential of oil spills created by the hazards of ice navigation. The U.S. Coast Guard, under the National Oil and Hazardous Substances Contingency Plan, would bear primary responsibility for coping with actual and potential spills.

The U.S. Coast Guard has developed a number of excellent contingency plans for spill clean-up and containment. Response time has been reduced to a few hours and good equipment is available. However, based on comments received on the Draft Report, Environmental Impact Statement, and the numerous public workshops and meetings, it appears that the public and agencies with the primary mission of protecting natural resources strongly desire further improvement of the ability to handle oil or toxic material spills. These agencies and the public have highlighted and the situation dictates that contingency plans, technology, and equipment continue to be improved to afford better protection for water quality and fish and wildlife resources which are essential to the health and economic well-being of much of the population of the Great Lakes Basin. These resources also form the basis of a multi-billion dollar tourist and recreation industry. Therefore, continued improvement of technology, technology transfer, contingency plans, and equipment is warranted and is proposed under the Environmental Plan of Action to afford the level of protection desired by the public.

A recently completed survey of cold regions oil spill mitigation technology included an investigation of the applicability of presently available means to the problems of detection, containment, recovery,

temporary storage, and disposal of oil spilled in cold regions characterized bv the existence of low temperatures and the presence of ice in its many forms. The evaluations were based upon the experience of various persons conducting cold regions laboratory and field programs, and the experiences of others in cold regions as reported in the technical literature. The survey revealed that a degree of oil spill response capability is available for use in cold regions based upon the techniques and equipment currently employed in warmer climates. While this capability is available, a great deal of development work must be undertaken before a total cold regions oil spill response capability is available which would satisfy the stated desires of the public and other State and Federal agencies.

Current technology falls short of the public's stated desired total response capability in all functional areas including remote sensing, containment, recovery, temporary storage, and disposal.[1]

If a spill should occur, ice and cold weather could affect containment operations, as well as oil recovery from stranded or sunken vessels. These and other considerations are important to contingency planning. The EPOA provides an opportunity to develop the desired level of clean-up capability.

However, it is possible to delineate some of the potential factors in oil spill contingencies and examine existing and proposed methods of handling them in the light of past experiences.

Summary of Responsibilities of the Fish and Wildlife Service

The Fish and Wildlife Service Interprets its responsibilities under the National Contingency Plan as Follows:

[1]Schultz, L.A., and Deslauries, P.C., "The Application of Existing Oil Spill Abatement Equipment to Cold Regions", 1977 Oil Spill Conference Paper No. 159, ARCTEC, Incorporated, Columbia, Maryland

OIL SPILL CONTAINMENT AND RECOVERY IN THE GREAT LAKES

ENVIRONMENT/ LOCATION	SPECIFIC PROBLEM	ALTERNATIVE SOLUTIONS: MOST PROMISING	ALTERNATIVE SOLUTIONS: POSSIBILITY	ALTERNATIVE SOLUTIONS: LEAST PROMISING	NOTES
I OPEN LAKE L. SUPERIOR L. MICHIGAN L. HURON L. ERIE L. ONTARIO	A. Prevent spills of oil and other hazardous substances (a).	1. Monitor hazardous material vessel movement. 2. Routine vessel inspection 3. Double hull requirements 4. Ice strengthened hulls 5. Collision avoidance systems (b) (LORAN-C all Great Lakes by 1980).		1. Limit vessel movement of hazardous substances.	(a) Existing problems year round. Coast Guard Contingency Plans exist in case of accidental spills per enclosure (1) (b) MINI-LORAN-C planned for Whitefish Bay; RACON'S (Radar Transponder Beacons) and ice buoy navigation aids in St. Marys River. St. Clair and Detroit River reach, and western Lake Erie to supplement LORAN-C, MINI-LORAN-C systems (g)
	B. Containment should spill occur on open water.	1. Booms 2. Cofferdams	1. Absorbents, if prior to oil aging. 2. Burning, if spill reached prior to wave induced emulsification. 3. Herding agents.	1. Dispersants, if threat to environment is imminent from spills of light oils, gases, naptha, or other hazardous substances. Effectiveness of dispersants diminished by oil emulsification. 2. Biodegradation not effective in cold water. 3. Detergents add undesirable chemicals to water.	
	C. Containment should spill occur on ice.	1. Shoveling gangs depositing oil into barrels. 2. Burning, if oil not covered by snow.		1. Burning, if mulch has been created by oil covered with recent snowfall. 2. Absorbents, dispersants, detergents and herding agents would be essentially ineffective in the absence of meltwater.	

(continued)

ENVIRONMENT/ LOCATION	SPECIFIC PROBLEM	ALTERNATIVE SOLUTIONS: MOST PROMISING	ALTERNATIVE SOLUTIONS: POSSIBILITY	ALTERNATIVE SOLUTIONS: LEAST PROMISING	NOTES
I OPEN LAKE (CONT'D)	D. Containment should spill occur under ice.	1. Boom containment for ice less than 4 inches thick by boom insertion following icebreaking. Booms may be inserted beneath thicker ice with skimmers deployed to remove oil from hole cut in ice upstream of boom. (presupposes thicker ice has smooth bottom.) 2. Pump oil out to boom or cofferdam for oil trapped under ice near icefree area. 3. Pump oil out onto ice surface for burning in ice locked locations containing thick ice.			
	E. Recovery of contained spill.	1. Pump contained oil that has not been burned or altered by dispersant to barge for transport to salvage treatment such as oil-water separation, or landfill dump. 2. Vacuum machines on barges. 3. Skimmers (c) (d). 4. Oil barrels filled by shoveling gangs, transported by barge to treatment or dump.			(c) Skimmers may be capable of recovering lighter oil following emulsification and aging. Heavy oils such as Bunker C, or No. 6 fuel and oil would probably coagulate and sink in the cold water lake environments. Divers would then be needed to manually retrieve the sunken oil from the lake bottom provided that bottom depths did not exceed diver limitations of approximately 135 ft. (d). Skimmers would not be effective in removing oil recovered by divers.

(continued)

ENVIRONMENT/ LOCATION	SPECIFIC PROBLEM	ALTERNATIVE SOLUTIONS: MOST PROMISING	POSSIBILITY	LEAST PROMISING	NOTES
I OPEN LAKE (CONT'D)	(E.) Cont'd.				(d) Methods of retrieving oil from depths in excess of diver limitations have not been developed.
	F. Recovery when oil contained vessel. 1. holed vessel afloat. 2. submerged vessel. 3. stranded vessel. 4. sunken vessel.	1. Debunkering to barge (e). 2. Heat pumps. 3. Steam at tank tops; debunkering. 4. 'Hot Tap' (f)		1. Use of chemicals not desirable for any situation. 2. Destroying vessel not desirable for any situation.	(e) Any or all 'most promising' oil recovery methods may be necessary in a given situation. (f) The 'hot tap' is essentially a heat pump applied to oil after holes are drilled in sunken vessel oil compartments (d).
II RIVER St. Louis River and St. Louis Bay, Duluth St. Marys River Chicago area waterways St. Clair-Detroit River reaches. Welland Canal St. Lawrence River, etc.	A. Prevent spills of oil and other hazardous substances (a)	See IA(1-5) (b) (g) 6. Vessel transportation system (h)		See IA(1)	(a) (g) Collision avoidance system with MINI-LORAN-C is planned for St. Marys River, St. Clair-Detroit River reach (b). (h) Precise all-weather navigation system is planned for St. Lawrence River.
	B. Containment should spill occur on open water (i).	1. Boom 2. Cofferdam	1. Absorbents, if prior to current induced emulsification. 2. Dispersants, detergents or herding agents may reduce impacts of oil spill in wetlands.	1. Burning not desired as result of current induced emulsification. 2. Dispersant, detergent chemicals may affect water intakes.	(i) The potential of rapid transport of oil by current would require immediate containment as part of the contingency plan(s) in effect for the location.

(continued)

ENVIRONMENT/ LOCATION	SPECIFIC PROBLEM	ALTERNATIVE SOLUTIONS: MOST PROMISING	POSSIBILITY	LEAST PROMISING	NOTES
II RIVER (CONT'D)	C. Containment should spill occur on ice (j).	1. Shoveling gangs depositing oil into barrels.	1. Burning in isolated areas not under fresh snow would limit area-wide decrease in ambient air quality. 2. Bulldozer for near-shore operations.	1. Burning mulch in populated areas. 2. Absorbent, dispersant, detergent, herding agent chemicals work poorly in absence of meltwater and may affect water intakes, wetlands.	(j) Oil trapped, on ice may permit time to develop multifaceted containment where open waters are not threatened.
	D. Containment should spill occur under ice.	1. Booms may be inserted beneath ice thicker than 4 inches with skimmers deployed to remove oil from hole cut in ice upstream from boom (presupposes ice has smooth bottom). 2. Pump oil onto surface of ice for burning.	1. Boom containment for ice less than 4 inches thick by boom insertion following breaking of ice allowing oil to move with current. 2. Pump oil out to boom or cofferdam confinement or ice entrapment near shore for skimmer removal provided that no water intake systems are nearby. 3. Use crane near shore to pick up oil "sandwiched" between old ice and newly formed ice beneath oil spill.	1. Absorbent, dispersant, detergent, herding agent chemicals may affect water intakes.	
	E. Recovery of Contained Oil.	1. Pump contained oil that has not been burned or altered by dispersants to barge for transport to salvage treatment. 2. Vacuum trucks near shore.	1. Crane transfer of "sandwiched" oil to barges or truck for transport to oil water separation, landfill dump.		c* Depths should not curtail diver operations.

(continued)

ENVIRONMENT/ LOCATION	SPECIFIC PROBLEM	ALTERNATIVE SOLUTIONS MOST PROMISING	POSSIBILITY	LEAST PROMISING	NOTES
II RIVER (CONT'D)	(E) Cont'd	3. Skimmers (c)* 4. Oil barrels filled by shoveling gangs, transported by barge or truck to treatment or dump. 5. Bulldozed oil placed on barges or trucks for transport.	2. Effectiveness of skimmers reduced in areas where oil is or has been transported by currents.		
	F. Recovery of oil contained in vessel. 1. holed vessel afloat. 2. submerged vessel. 3. stranded vessel. 4. sunken vessel (k).	See IF(1-4)(1)		See IF(1-2)	(e) (f) (k) 'Puff' devices whereby foam balls are inserted into nets attached to hull of sunken vessel to raise it. (l) The essentially 'fixed' environment of oil contained in vessels should not involve significantly different recovery methods from those covered in IF.
III HARBORS All Great Lakes and River Systems	A. Prevent spills of oil and other hazardous substances.	See IA IIA		See IA IIA	(a) (b) (g) (h)
	B. Containment should spill occur on open water (m)	1. Booms 2. Cofferdams	1. Herding agents to avoid spread of oil to water intakes, wetlands. 2. Absorbents, if they are deployed rapidly.	1. Burning not desired since ambient air quality would decrease.	(m) The proximity of a number of city or industrial water intakes would require immediate containment as part of the contingency plans in effect for harbors.

* See next page

(continued)

ENVIRONMENT/ LOCATION	SPECIFIC PROBLEM	ALTERNATIVE SOLUTIONS MOST PROMISING	POSSIBILITY	LEAST PROMISING	NOTES
III HARBORS (CONT'D)	(B) Cont'd		3. Dispersants, detergents may reduce impacts of oil spills to wetlands.	2. Dispersant, detergent chemicals may affect water intakes.	
	C. Containment should spill occur on ice (j).	See IIC	See IIC	See IIC	(j)
	D. Containment should spill occur under ice.	See IID	See IID(n)	See IID	(n) Skimmers should be deployed to open water containment point for recovery of oil driven out from under ice. Driving oil out to open water near shore, in contrast to river environments (Possible Alternatives IID), should be avoided wherever possible due to nearshore water supply systems, marinas, etc.
	E. Recovery of contained oil	See IE, IIE where applicable c*	use of cranes (see IIE)		c* Depths should not curtail diver operations.
	F. Recovery of oil contained in vessel.	See IF IIF		See IF IIF	(e) (f) (k) (l)
	1. holed vessel afloat.				
	2. submerged vessel.				
	3. stranded vessel.				
	4. sunken vessel (k)				

1. To provide a member or alternate member to the NRT and RRTs who will respond to pollution incidents when these teams are activated, and participate in regional contingency planning.

2. To develop and implement FWS regional response capabilities for the protection of wildlife and fisheries resources and their habitats, including all contingency planning necessary to fulfill obligations set forth under Section II of this plan.

3. To coordinate initial response activities should FWS representative be the first Federal person at a spill site, as provided in the National Contingency Plan, and in cooperation with other State and Federal agency representatives.

4. To prepare for, oversee and/or implement dispersal of wildlife from areas contaminated by or threatened by polluting discharges.

5. To determine how, by whom and where oiled migratory birds and other wildlife under FWS jurisdiction shall be handled in event of a spill. If oiled birds are not to be treated by personnel of a Federal or State agency, to arrange for and coordinate actions of professional and volunteer groups that wish to establish bird collection, cleaning and recovery centers.

6. To provide the OSC with recommendations of actions for protection of fish and wildlife resources, including but not limited to migratory birds, marine mammals, endangered species, estuarine and inland water fisheries and their habitats.

7. To assist in documenting environmental damage caused by oil and hazardous substance discharges for use in legal actions and in predicting impacts of future discharges and other responsibilities as delineated in Section II of this Plan.

Reference: Pollution Response Plan for Oil and Hazardous Substances, U.S. FWS, DOI, 1 June 1977

Potential for Pollution Accidents in an Ice Environment

A discussion of oil pollution in ice conditions should begin at one likely source of such pollution--vessels. During spring navigation, when greater ice damage is likely, such damage is usually to the bow, screw or rudder and does not result in oil spillage. Actual experience during late season navigation during the past six years in newly formed ice has resulted in minimum ice damage to vessel hulls. The potential for oil spills resulting from foundering is not very significant for vessels which do not carry fuel in double bottom fuel tanks, except for tankers. A good example is the minimum oil spill that accompanied the grounding of the ore carrier CASON J. CALLOWAY in the vicinity of the Lansing Shoals on 21 March 1975.

The greatest danger posed by ice damage seems to be in the premature movement of some 90 to 100 vessels ill-equipped to navigate in the lingering ice of late March and April. During the 1969-70 and 1970-71 ice seasons, there were 21 and 7 such cases, respectively, which accounted for 95 percent of the ice damage accidents in those seasons. The trend continued in the 1971-72 through 1974-75 seasons which saw a total of 30 ice related accidents, 25 of which occurred during the opening of the regular season rather than during the extension of the season. More than half of these accidents occurred in Whitefish Bay and at the southeast corner of Lake Superior near the heavily transited St. Marys River. Fortunately, since most of the accidents involved bow or screw damage, there was no pollution. It might be emphasized that extending the navigation season reduces the urgency to resume operations in the early spring. Improved weather and ice forecasting techniques could, along with the Coast Guard's request that vessels not properly designed or reinforced

for ice operations refrain from operating in late winter or early spring, further minimize premature navigation. An oil spill scenario for the St. Marys River is presented below.

Oil Recovery Strategies

St. Marys River Scenario. During the extended season, potential pollution incidents involving vessels could be due to collision with ice, another vessel or an obstacle, to grounding, or to accidental spillage in transfer operations. Any of the above could be the result of, but not necessarily limited to, operation of vessels that are not adequately powered and/or not properly strengthened, or properly constructed and certified for winter navigation. The following is extracted from "Systems for Arctic Spill Response" prepared by Arctec Inc. for the U.S. Department of Transportation-U.S. Coast Guard.[2] While the primary emphasis of this program was placed on the coastal and offshore regions of Alaska, it was recognized that the approach developed for oil spill response in offhsore Alaska may be applicable to some degree in other subarctic ice covered waters of the lower 48 states. The above study therefore icluded the evaluation of the alternative Coast Guard arctic oil spill response system for application in seasonally ice covered waters of the lower 48 states. The approach used in the development of subarctic systems requirements closely paralleled the approach used for the arctic cases with the study based upon selected oil spill scenarios.

As a result of the study, it was determined that the presence of ice sometimes helps and sometimes hinders the spill response effort. On the basis of the spill response scenarios developed in the study, there appears to be a substantial amount of spill response capability based on current technology and currently available equipment. Some additional equipment needs to be developed, however, and the suitability of the proposed techniques must be demonstrated in most cases through laboratory and field test programs. The type of oil involved in the spill and the environmental

[2] Schultz, L.A., Deslauriers, P.C., DeBord, F.W., Voelker, R.D., "Draft" - Systems for Arctic Spill Response 1978 prepared by Arctec, Inc. for U.S. Dept. of Trans., U.S. Coast Guard. Document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161

conditions surrounding the spill situation result in the establishment of practical limitations to the level of response capability which can be achieved. The most cost effective response levels were found to be the lower to intermediate response levels. In several cases, a high response level of 80% required the use of a special oil/ice recovery vessel which has the capability of recovering and cleaning oil contaminated ice in addition to recovering the oil left in an open water condition after removal of the ice. The special oil/ice recovery vessel, which does not exist at the present time, was, however shown to be non-cost effective. The optimum arctic pollution response system is basically a combination of equipment lists developed for the various spill scenario/response level combinations, with appropriate adjustments made for commonality. No single approach applies universally to all arctic oil spill scenarios, therefore, there is no piece of universally applicable oil spill response equipment. In a similar manner, the spill situations addressed by the sub-arctic spill scenarios are, in turn, distinct from the arctic scenarios, and are distinct from each other; therefore, a combination of equipment is again required to achieve the desired response capability for subarctic ice infested waters.

Spill Scenario - St. Marys River

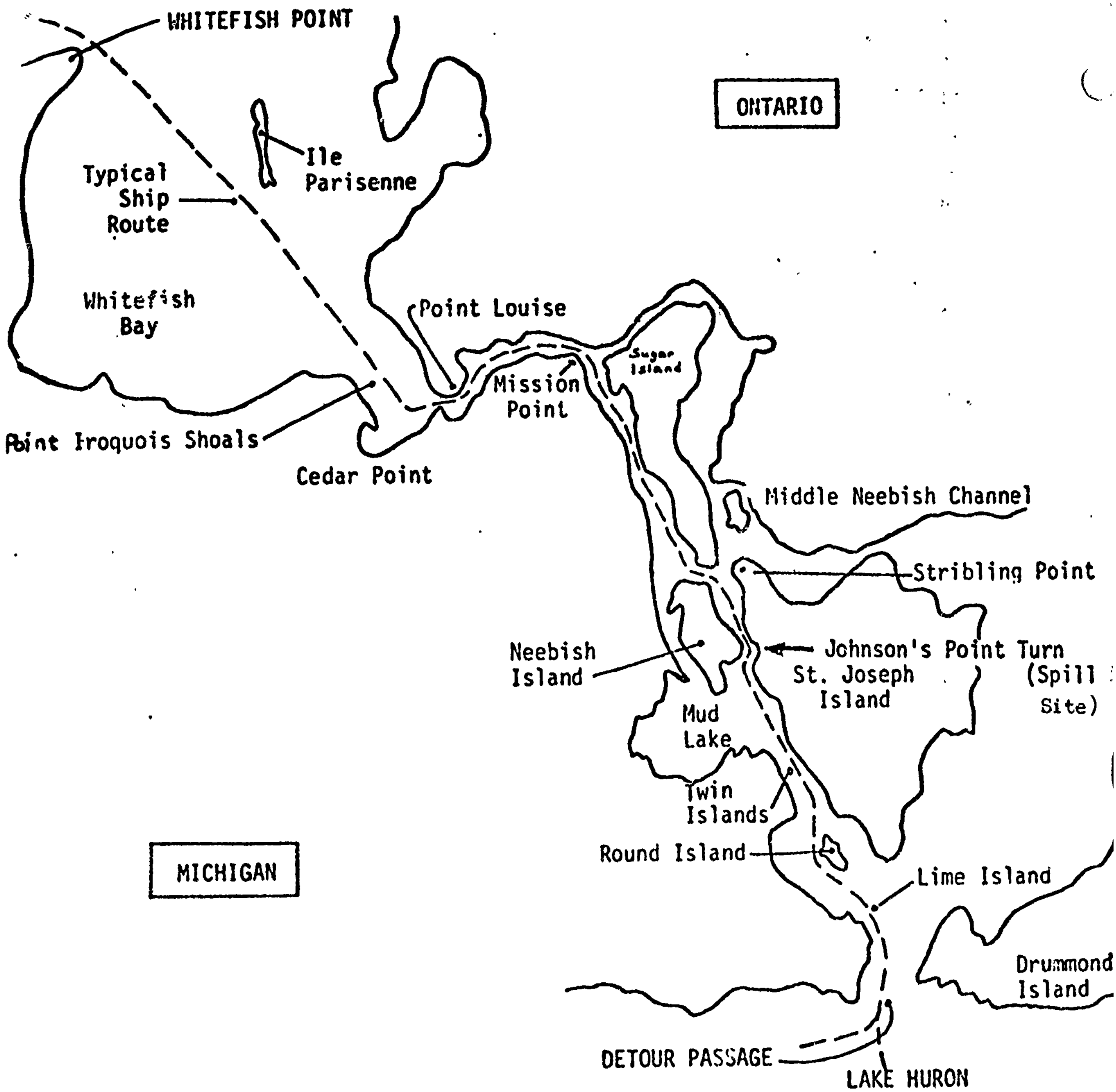
On the Great Lakes, several alternative spill scenarios can be developed and evaluated on the basis of both spill potential and environmental severity. The examination of spill potential can be related to the level of marine traffic, water depth, and ease of navigation. The greatest potential for marine casualty is in the connecting waterways between the Great Lakes. This would involve such areas as the St. Marys River, the Mackinac Straits, the St. Clair River, and the Detroit River, to name a few. Having established that the connecting waterways are the areas for greatest probability of a ship casualty due to restricted navigable channels and ice jamming as defined in the previous section, it now becomes necessary to establish which of the connecting waterways should

be used for the spill scenario. The St. Marys River has been selected because of the high traffic in the waterway during extended season operation and the severe ice conditions that are present. Although petroleum product traffic on the St. Clair-Detroit River system is greater, ice conditions on the St. Marys River are more severe and the total number of vessels operating in the winter is much greater.

The site selected within the St. Marys River is at Johnson's Point Turn, which is the sharpest turn in the river system, and where all ship maneuvers occur within a dredged channel. For this scenario, it is assumed that a tanker grounding at Johnson's Point Turn occurs in February and 10,000 barrels (420,000 gallons) of No. 6 residual fuel oil are released. The location of the spill is shown in Figure IV-1.

Spill Mode. The spill mode selected for the Great Lakes oil spill scenario consists of a tanker grounding at Johnson's Point Turn in the St. Marys River resulting in the rupture of three cargo tanks and the instantaneous release of 10,000 barrels of No. 6 residual fuel oil. The tanker grounding is selected to take place in February when the channel is 100% clogged with broken ice contained by level ice outside of the channel.

Spill Environmental Conditions. The ice cover at Johnson's Point Turn in February, March and April is characterized by a broken ice field in the navigation channel, bordered with level shorefast ice outside the channel. Typical thicknesses of the level shorefast ice outside of the navigation channel are 19 inches in early February, increasing to 23 inches by late February, then holding at about 20 inches throughout March, and decreasing to 8 inches by the end of April. The thickness of the broken ice in the navigation channel increases from 39 inches in early February, to 47 inches by the end of February, leveling off at 52 inches in March, and decreasing to 16 inches by the end of April. Mean air temperatures are typically 16°F in February and 24°F in March. Minimum air temperatures will



MAP SHOWING THE SELECTED GREAT LAKES SPILL SITE
AT JOHNSON'S POINT TURN, ST. MARYS RIVER

FIGURE IV-1

typically be 7°F in February and 16°F in March. The water temperatures will be 32°F. The controlling depth of water in the St. Marys River is 28 feet. The average water curre.:r at Johnson's Point Turn will be 1 knot.

Visibility at Johnson's Point Turn will typically be reduced to less than 1/4 mile due to fog or blowing snow one to two days in February, and for as much as 1 week in March. There will be at least 8 hours of daily daylight throughout the winter months. Approximately 8 inches of snow can be expected to be on the ground at the time of the spill, with 3 to 6 inches of additional snow fallig within one week of the spill. The average monthly snowfall is 19 inches in February and 15 inches in March. Winds will typically be 10 mph from the east in February and 10 mph from the west-northwest in March. Maximum observed wind speeds have been recorded as 72 mph in February and 60 mph in March. Waves will not be a factor in the area due to the ice cover. February is typically storm-free, and one storm can typically be expected in the month of March.

Spill Behavior. Th. oil spill scenario is based on the assumption that the tanker grounds at the edge of the channel on the inside of the turn along the west bank. As shown schematically in Figure IV-2, the one knot current will carry the oil downstream into the channel south of Johnson's Point. Since the specific gravity of No. 6 fuel oil at 32°F is 0.96, the oil will float up into the stationary broken ice in the channel where it will be sheltered from the current and remain in place. A relatively small amount of the oil is expected to be swept under the level ice outside of the navigation channel. This distribution of oil in the rubble ice field of the navigation channel and beneath the adjacent sheet ice is shown schematically in Figure IV-3.

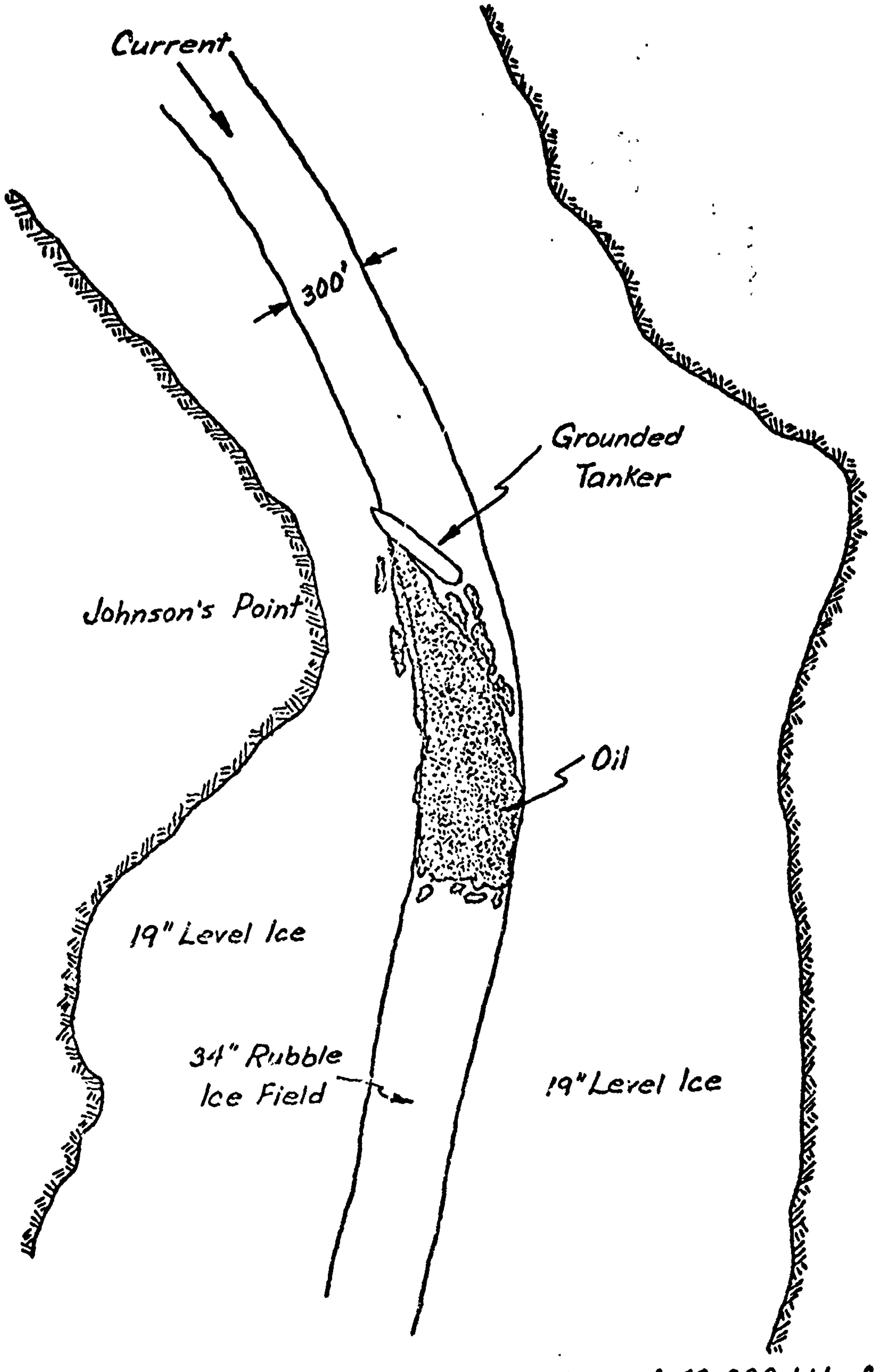
Assuming that 90% of the spilled oil is carried into the rubble ice field in the navigation channel, which is further assumed to be 50% solid ice pieces and 50% water by volume, the oil will be contained in a 19 inch layer by the surrounding level ice, and the area coverage of the spill in

the channel will be approximately 64,000 sf. The remaining 10% of the spill is assumed to locate beneath the level ice, which when spread to an equilibrium thickness of about 1 inch, would contaminate an additional 63,000 sf of the ice cover. This, however, is judged to be an extreme situation, and unlikely since the oil will probably remain concentrated near the edge of the channel at significantly greater thicknesses, since the oil will solidify as it cools below its pour point of 34°F.

Losses due to weathering are assumed to be only about 5% by the end of two weeks since the oil is residual fuel oil with few light fractions, and since only a portion of the oil will be exposed to the atmosphere at 16°F. Oil penetration into the ice pieces in the broken channel will be minimal since fresh water ice is relatively non-porous. Oil will, however, be frozen in pockets between the ice pieces after the oil comes to thermal equilibrium in the ice field. The oil will solidify in these pockets since its pour point of 34°F is above the water temperature of 32°F and the air temperature of 16°F. Since the ice is in a growing condition at the time of the spill in early February, the oil will be frozen within the ice field. Any snowfall occurring after the spill will cover the exposed oil with very little absorption of oil by the snow.

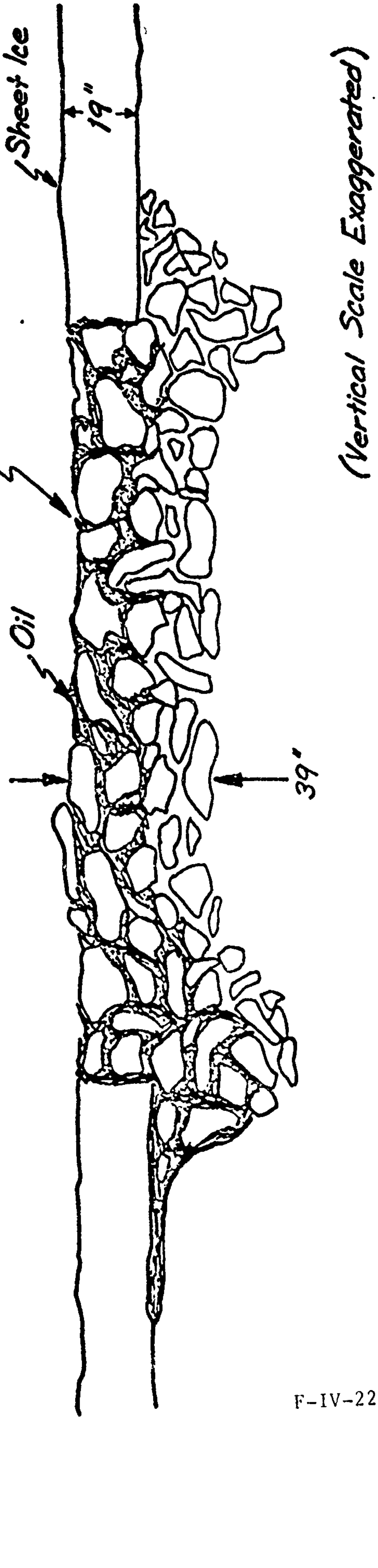
According to the U.S. EPA, oil which remains exposed to the river current and is not frozen into the ice can begin to accumulate sediment particles from the water and can begin to sink due to the density of the oil/sediment mixture. This oil would travel down the river, depositing on the river bottom in unpredictable locations -primarily those areas of lower current velocities. In spring, this oil would again begin to float as the temperature rises. What percentage of the oil would undergo this process cannot now be postulated.

Spill Response. The spill will be detected by the crew of the tanker immediately after the grounding occurs. The accident will then be reported to the Coast Guard at Sault Ste. Marie by ship's radio. All ship traffic to the affected area will be stopped.



Conceptual Sketch of the Spill of 10,000 bbl of No. 6 Fuel Oil at Johnson's Point Turn

FIGURE IV-2



Schematic Representation of the Distribution of the Oil in the Ice Field Shortly After the Johnson's Point Turn Oil Spill.

FIGURE IV-3

Initial surveillance will be accomplished by the crew of the tanker until Coast Guard vessels arrive from Sault St. Marie. Subsequent visual surveillance will be provided by Coast Guard personnel from the Coast Guard vessels and from a Coast Guard helicopter. All significant pools of oil within the affected area will be marked as soon as possible so that they can be located even in the event of a snowfall. It is estimated that one helicopter overflight per day will be required throughout the period of spill response operations to assure that the oil is indeed contained with the broken ice field and not moving downstream from its original location. Such surveillance could not provide information on that part of the oil which might begin to sink and go downstream.

While it is conceivable that an ice boom could possibly be used to move the broken ice/solidified oil mixture closer to shore to allow the conduction of a shore-based cleanup operation, the remoteness of the area makes shore-based cleanup impractical. As a result, the preferred response requires a cleanup operation based on the use of marine vesels. Since there will be substantial natural containment of the spilled oil by the ice cover, there are no additional requirements for containment, assuming that the response operation is completed prior to breakup of the ice field. As break-up begins, surveillance would have to be maintained over the downstream reach of the river and part of Lake Huron to see if any sunken oil begins to float up. Upon identification of such a situation, equipment would be brought in to contain and remove the oil.

Since the level ice cover surrounding the navigation channel is not adequate to support heavy vehicles and equipment, and shore-based recovery is not feasible due to the remoteness of the area, all recovery operations must be carried out from marine vessels. The west bank of the river on Neebish Island is only accessible over ice covered dirt roads, and no vehicles heavier than snowmobiles can cross the Oakridge Ice Bridge on the

eastern bank of the island. On St. Joseph Island, which forms the east bank of the river, similar road conditions exist. Therefore, over-land transit of recovery equipment and recovered oil and ice will not be possible. The condition of the residual oil and the ice in the navigation channel, along with the low air temperatures, eliminates several recovery options. The successful burning in situ of small pockets of somewhat weathered solidified residual fuel oil is unlikely. Also, since the oil will be at a temperature below its pour point, the use of direct suction devices and pumps is not possible. Conventional oil spill recovery devices will also be ineffective since the oil and ice cannot be readily separated due to the solidification of the oil. The preferred response therefore consists of a system capable of processing large pieces of broken ice and intermixed oil. The physical recovery of the oiled ice is required, followed by processing to separate the oil from the ice. For the 25% and 50% response levels, it has been estimated that recovery could be accomplished through the use of a clamshell or dragline dredge operating with a hopper barge. One crane and nine men would be required for a period of six days to achieve the 25% response level, and twelve days to achieve the 50% response level, with crews working eight hours per day in both cases. An icebreaker would be at the scene to assist in recovery operations. Further increasing the response level to 90% will require that all of the oil in the channel, and some of the oil beneath the adjacent level ice cover, be recovered. It is envisioned that a special oil/ice recovery vessel, similar to the unit proposed in some of the arctic spill response scenarios, would be necessary to achieve this response level. Some type of conveyor recovery mechanism would be necessary so as to eliminate the losses associated with the drain-off from the clamshell or dragline type of recovery operation. A device having this capability does not currently exist, but might be developed pursuant to the EPOA investigations.

All temporary storage requirements would have to be met by marine vessels since the use of containers on top of the ice is not feasible, and

the remoteness of the area precludes over-land transfer. Because of the large volume required for storage of the recovered oil/ice mixture, hopper barges will be the preferred means for temporary storage. These barges need not be ice strengthened if they are escorted to the spill site by Coast Guard icebreakers. Storage capacities of 2,100 cubic yards, 4,200 cubic yards and 9,500 cubic yards would be required for the 25, 50 and 90% response levels, respectively. Since the recovered oil and ice will be deposited directly in the barges and stored in the barges until spring, no further storage facilities will be required.

The response scenario is based upon allowing the oiled ice in the hopper barges to melt naturally as temperatures icrease in the spring. Once melting has been completed and the oil is separated from the ice, temperatures will be such as to allow transfer of the oil from the barges to onshore disposal site through the use of conventional pumping systems. The stricken tanker will be offloaded to permit its removal from the shoal. A tank barge with a steam generator and an ADAPTS pumping system will be required for offloading the tanker.

The preferred response calls for disposal of the oil to onshore oily waste processing plants after the oil has been separated from the ice by allowing the ice to melt in the hopper barges.

The logistics effort associated with this spill response scenario will be primarily marine based. Coast Guard vessels and personnel will proceed to the spill site from Sault Ste. Marie as soon as the accident is reported to serve as the onscene command and communications center. A helicopter will be made available at the site to assist with surveillance and emergency evacuation as necessary. The barges and the associated equipment required for recovery will be brought to the site from Chicago, with an icebreaker escort arriving on scene about 5 to 7 days after the spill occurs. Accommodations for the spill response team will be provided aboard the vessels responding to the spill.

Weather forecasts will be important for the guidance of the spill response operation. Ice forecasts and an oil spill behavior model will not be necessary since both ice and oil conditions will have stabilized shortly after the spill occurs. Paramedical facilities will be available on the Coast Guard icebreaker, and emergency cases can be flown by helicopter to Sault St. Marie.

The preferred spill response techniques determined for the Great Lakes spill scenario at Johnson's Point Turn of the St. Marys River are summarized for the three levels of response capability in Table IV-1. The equipment required to achieve each response level for this scenario is identified in Tables IV-2 and IV-3.

Removal of Oil from Vessels

In removing oil from a stranded vessel, there are a number of methods which involve a minimum danger of spillage. One method is by opening the vessel's tanktops and allowing the oil to flow into a compartment that is not open to the sea. Another is the utilization of the vessel's piping system. The piping system may be damaged, but the possibility of using the system should not be overlooked. Both of these methods have been successfully employed in two recent salvage cases on the Great Lakes. Energy may, of course, be available on the stricken vessel, but it is more likely that auxiliary power supplies would be required.

In one of these instances, the viscosity of the unheated heavy oil hampered pumping operations through the tanktops and led to discovery of a "cone effect". The suction line sucked an inverted cone-shaped hole through six feet of oil to the water below, which had entered through the holed bottom of the tank. Thinning agents proved ineffective in promoting oil flow, and pumping was eventually successful only by the introduction of steam at the tanktops.

TABLE IV-1. SUMMARY OF PREFERRED SPILL RESPONSE TECHNIQUES FOR THE GREAT LAKES SPILL SCENARIO

Function	25% Response Level	50% Response Level	90% Response Level
Detection	Visual by crew of grounded tanker	Same	Same
Surveillance	Initially by tanker crew then by Coast Guard personnel from ship and helicopter	Same	Same
Containment	Natural	Same	Same
Recovery	Clamshell or dragline dredge	Same	Special oil/ice recovery vessel*
Storage	Hopper barge	Same	Special oil/ice recovery vessel*
Transfer	Conventional pumps	Same	Special oil/ice recovery vessel*
Disposal	Shore side oily waste processing plant	Same	Special oil/ice recovery vessel*
Logistics	Coast Guard Vessels from Sault Ste. Marie, barges and tugs from Chicago	Same	Same
Ancillary	Daily weather forecasts	Same	Same
Emergency Evacuation	Paramedical facilities on icebreaker, helicopter for emergency cases	Same	Same

*Does not now exist, plans have been developed, and should the EPOA determine a need, the vessel could be built.

TABLE IV-2. EQUIPMENT REQUIRED TO ACHIEVE THE 25 PERCENT RESPONSE LEVEL FOR SCENARIO NO. 7

Subsystem	Item	No. Req'd.	Specifications	Weight/Volume
Surveillance	Helicopter	1	Buoyant, disposable	
	Surface markers	200		
Containment	None			
Recovery	** Crane barge	1	Clamshell or dragline on 4,000 yd^3 barge	
Storage	Tank barge	1	10,000 bbl with a steam generator and pumps	
Transfer	ADAPTS pumping system	1	1000 gpm @ 32 ft disch.	
Disposal	None			
Logistics	Tugs	2		
	Icebreaker	1	MACKINAW or Wind Class	
	C-130	1		
	Special Clothing	10 sets	Low temperature, oil resistant	
Ancillary	Weather forecasts	daily		
	Communications equipment			
Emergency Evacuation	Helicopter (listed above)			

**Demonstration required.

TABLE IV-3. VARIATIONS IN EQUIPMENT REQUIRED TO ACHIEVE THE 50 PERCENT and 90 PERCENT RESPONSE LEVELS FOR SCENARIO NO. 7

Response Level	Surveillance	Containment	Recovery	Storage	Transfer	Disposal	Logistics	Ancillary
50%								
90%			ADD: *Oil/ice recovery vessel (1) DELETE: **Crane barge (1)	ADD: Hopper barge (1)				

* Research and development required.
** Demonstration required.

In early 1970, the first major North American oil spill in the presence of ice triggered a multi-faceted recovery operation that had great implications for cold weather tactics. On 4 February 1970, a tanker of Liberian registry smashed into Cerberus Rock in Chedabucto Bay, Nova Scotia, rupturing several fuel tanks. Within four days, pounding seas broke the ship in half, spilling additional oil into the bay. Of the vessel's original cargo of 3,850,000 gallons of Bunker C fuel oil, an estimated 2,350,000 gallons blanketed neighboring waters and shorelines and 1,500,000 gallons remained on board.[3]

It was apparent that the oil would have to be heated in order to make pumping feasible, as the viscosity of the Bunker C oil, which has a pour point of 30°F, made it more like toothpaste than oil.

It could be assumed, however, that the specific gravity of the Bunker C (estimated at 0.994 at 34°F, as compared with 1.024 for seawater) would cause it to rise. This factor raised the possibility of using cofferdams and supported the prospects of pumping the oil. Cofferdam proposals were rejected in view of severe sea conditions anticipated and foreseeable engineering difficulties. Cofferdams offered no way of keeping the oil under positive control, compared with pumping methods.

To prevent the tanks from collapsing and to permit seawater to exert an upward force on the oil during pumping, holes could be cut in unholed tanks.

Also considered was a suggestion to raise the temperature of the oil in the sunken vessel by injecting heated oil from a salvage barge. This proposal was rejected after shore studies confirmed that the probability of heat transfer was low and that hot oil would probably not mix with the Bunker C oil.

[3]Crowley, Richard W., ARROW NAVASHIPS 0994-006-1010

The method finally decided upon was drawn from the oil industry's use of an inclosed rotary cutter device (called a "hot tap") to drill holes in refinery pumping systems while maintaining the flow of oil during drilling. Preliminary diving tests showed that the method was indeed workable and recovery operations began in the middle of March, supported by a diving tender, a salvage ship, and an oil transfer barge.

Saturated steam at 100 psi and 300°F was circulated through metal hoses to heat the Bunker C oil as it was pumped upward to the tanks of the storage barge. Steam trace configurations were of three types; open steam with J-fitting; open steam with straight fitting; and closed loop. The first two heated the oil more effectively by discharging the mix of steam and condensate into the oil at the bottom of the suction hose, but the closed loop design did have the advantage of conserving boiler feedwater--a critical logistical consideration in the marine situation. In the Great Lakes, however, feedwater would not be a limiting factor.

All of the steam trace designs succeeded in raising the discharge temperature of the Bunker C oil to over 100°F, and contributed to individual hose pumping rates which were in the range of 4,000 to 6,000 gallons per hour.

Other methods of injecting heat via steam were tested, with inconclusive results. Airlift techniques were also tried briefly in an effort to increase the pumping rate. However, these did not prove successful.

Following the completion of debunkering, the U.S. Navy called for accelerated development of electric submersible pumps and airlift techniques, in view of lower logistic support requirements. The Navy also urged the development of electrical immersion heaters for tank penetrations and resistance heaters to be built into suction hoses. It was recommended that all tankers be fitted with deck and hull access connections to facilitate lighterage operations.

Other methods for penetrating the hulls of sunken ships have been proposed, including the large pneumatic hole punch.[4] Such a device, which is designed to operate on the principle of a recoilless rifle, is powered by compressed air. Apparently this method has not yet been tested on sunken vessels, but it may offer considerable savings in bottom time for divers. "Hot tap" drilling required 12 hours of diver bottom time to set up, and in most stages of the process required two divers.

All current hull penetration methods require divers, which imposes a practicable working limit of 135 feet in depth. Weather and the presence of oil can greatly complicate this human factor, particularly in water close to freezing temperatures.

In the Great Lakes, contingency planners would have at least two advantages over planners in coastal regions with respect to sunken vessel operations--the more uniform, shallower river channels, and the presence of fresh feedwater for steam driven pumps.

Additional Sunken Vessel Strategies

There are two other possibilities for eliminating the oil threat for sunken vessels, particularly tankers, in addition to the salvage techniques discussed above. The first is to destroy the vessel and concentrate on recovering or treating the oil on the surface; the second would be to treat the oil in the vessel.

Destruction of the vessel would pose potential environmental hazards. Surface oil can be treated by the chemical, biological, or mechanical methods discussed below, but only under relatively ideal weather conditions. In addition, known biological methods are extremely slow. Additional research is necessary before they could be deemed feasible.

[4] Rose, V.C.; and Soltz, F.C., "Removal of Oil From Sunken Tankers" in Proceedings of the Joint Conference on Prevention and Control of Oil Spills, American Petroleum Institute, Washington, D.C., 1971

The second method would require the introduction of chemical or biological agents into fuel tanks, a stirring action to ensure reaction, and protection of the tanks against rupture until the oil was rendered harmless. As yet, no chemical or biological agents have proven successful for this kind of application.[5]

Therefore, at present, oil salvage appears to be the best immediate strategy for removing oil from stricken vessels with much of current research being directed towards improving existing techniques. Private enterprise is developing more easily transportable electric submersible pumps and is investigating new methods for improving pumping rates by heating the oil more efficiently. Ultrasonic and microwave heaters, that would be placed in oil tanks and used in conjunction with integrally heated suction hoses, are two additional ideas that have been proposed to speed the process of oil removal and to lower the chances of further oil loss due to wreck shifting and bad weather.

New ideas have also been proposed for raising sunken ships in protected waters, including a "puff" device that would insert foam balls into nets attached to the hull of a sunken vessel.

Types of Oil Spills in an Extended Navigation Season

Oil spills in an extended navigation season would fall into one or a combination of the following categories:

1. Spills in water,
2. Spills on ice, or
3. Spills under ice.

Each situation could call for different strategies, based on what is known of the behavior of oil in that situation.

[5]Rose and Soltz, op. cit.

Oil Spills in Water. The movement of oil cargoes in any type of weather condition is never completely safe, and at least one authority has estimated spillage to be on the order of 0.1 percent of the total quantity transported.[6] It is possible that this percentage would increase under ice navigation circumstances for vessels not designed to operate in ice and decrease for those vessels that are specially designed, strengthened and powered for such operations. It has been suggested that regulations be established which set the criteria that would be acceptable for wintertime operation on the Great Lakes. Congress has begun considering at least 11 separate legislative proposals for preventing spills of oil in U.S. waters, including the Great Lakes.

If oil is spilled in open water, whether during an extended navigation season or not, the choice of cleanup procedures would depend on a number of variables, including wind, seas, presence of ice, and the properties of the oil.

The temperature of the water may actually aid in cleanup, since colder temperatures would increase the viscosity of the oil and tend to restrict its movement. Loss of higher volatile constituents through evaporation, a process known as aging, however, is also reduced in cold temperatures.

Waves and currents have the greatest effect on oil dispersal, causing the oil to break up into globules and mix with water to a certain extent in a process called emulsification.

Ice tends to act as a boom, restricting the movement of oil and lowering the effect of wind. Heavy fuel oils, such as that of Bunker C, have a much lower tendency to spread in water with temperatures near freezing, and the presence of ice would cut movement down still further.

Many of the techniques used in temperate weather spills could also be used in colder weather, although some would be greatly hampered by the presence of ice.

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[6] Blumer, M., "Oil Pollution of the Ocean", in Oil on the Sea, ed by D.P. Hoult, Plenum Press, New York, 1969

Containment. The first priority in a spill on water is speedy containment, particularly if the spill is of such magnitude as to make dispersal an undesirable alternative. The need of a prompt response is further intensified in rough seas where wind and water could combine with the dispersed oil, yielding an emulsion; and also, in a river situation where river currents can increase the dispersal rate.

In general terms, oil containment booms are used to restrict the area covered by an oil spill. This also results in the gathering of the oil into a thicker layer which generally results in more efficient recovery operations. While a great variety of floating containment booms have been developed, both laboratory testing and field experience have shown that their usefulness is limited by forces exerted by the environment.[7]

Cold weather booms must be of especially sturdy structure because of the pressure of ice. In tests, sub-freezing temperatures did not affect the operation of booms or cause cracking. Therefore, it could be surmised that existing booms could be used in fairly cold conditions, although they should not be expected to withstand the pressures exerted by heavy ice. The Canada/U.S. Joint Response Team (for oil and hazardous substance spills) is at present developing an ice boom, the purpose of which is to deflect flowing ice while permitting fluids (oil and water) to pass through the boom, permitting containment below the boom with conventional devices. Aside from this project, there is little research effort presently being devoted to the problem of oil spill containment in cold regions.

To summarize, ...while commercially available oil containment booms (have been) judged to have promise for limited successful application in cold regions incorporating light and moderate broken ice fields, it is clear that no presently available oil containment boom is suitable for general application in cold regions in the presence of large broken ice pieces.[8]

[7] Schultz and Deslauriers, op. cit.

[8] Ibid.

The spreading of oil on protected water is thought to be controlled by four physical phenomena: gravity, surface tension, inertia, and viscosity. Liquid chemicals called herding agents tend to decrease the area of an oil slick by lowering surface tension until gravity forces are in equilibrium with surface tension forces.

Herding agents have not been extensively tested in a cold water environment, but it is anticipated that their effect would be negligible, due to the increased viscosity of oil caused by low temperatures. Another drawback to their use is the undesirability of adding more chemicals to an already polluted environment.

Recovery Methods. Once confined, the oil could be recovered by a variety of methods. A favorite technique used in protected areas is the use of skimmers or vacuum trucks. Skimmers have not yet, however, been proven effective in open water or ice conditions. They were employed very successfully in the Chedabucto Bay spill, but only in sheltered water. One commercially available skimmer has been used in open sea conditions, but had a disappointing collection rate of only 30 percent. Potential skimmer systems, such as the double weir, rotary disk, and incline plane, promise much higher recovery rates and easier transport.[9] A continuous fibrous rope unit... (has been) judged to have a degree of applicability in recovering oil spilled in broken ice fields, on top of solid ice cover, and beneath solid ice cover. No presently available device is universally capable of recovering oil spilled on, beneath, or sandwiched within ice, under all ice conditions.[10]

If an open water spill congregates in relatively ice-free bays and harbors, small skimmers used in gangs could prove to be an effective means of recovery.[11]

[9] Irons, D.E., "Oil Pollution and Ship Salvage, "Technical News, Naval Ship Systems Command", October 1972

[10] Schultz and Deslauriers, op. cit.

[11] McLeod, W.R., and McLeod, D.L., in "Measures to Combat Offshore Arctic Oil Spills", a paper delivered to the Offshore Technology Conference, Houston, Texas, May 1972

As part of its Arctic pollution response program, the United States Coast Guard recently completed a two phase testing program of oil spill recovery devices operating in a broken ice field at below freezing temperatures. The Phase I program consisted of tests of oil spill recovery devices to determine their performance when operating in an oil/ice/water environment. Tests were conducted in both salt and fresh water ice, with No. 2 fuel oil and a crude oil similar to Prudhoe Bay crude oil, and in nominal oil thickness of 1/2 inch and 2 inches. These tests demonstrated that with minor hardware modifications and the proper operating procedures, both devices can successfully recover oil spilled in a broken ice field of moderate ice piece size. The Phase II test program, was primarily directed towards the evaluation of modifications intended to improve the performance of the devices when operating in broken ice cover, and the determination of the variation in oil recovery performance with variation in forward speed and drum or belt rotational speed. Among additional secondary tests incorporated in the Phase II program were spreading tests to determine the natural equilibrium slick thickness of the oils tested, and brief oil recovery performance tests of the oil recovery devices at low temperatures in open water. Tests of the modified devices demonstrated that the modifications did improve their performance when operating in broken ice cover. The spreading tests demonstrated that light oils will spread to a very thin layer, whether in open water or in broken ice cover. Heavy oils in broken ice cover will, however, achieve a natural equilibrium thickness many times greater than the open water thickness due to the partial containment of the oil by the broken ice pieces.[12]

Another promising method of oil recovery is the use of absorbents, such as straw, peat moss and certain chemical foams. Laboratory tests have

[12] Getman, J.H., U.S. Coast Guard, and Schultz, L.A., ARCTEC, Inc., "Tests of Oil Recovery Devices in a Broken Ice Field", Paper No. OTC 2695, a paper delivered to the 8th Offshore Technology Conference, Houston, Texas, May 1976

demonstrated that polymeric foams have greater absorption capabilities than inorganic and natural organic materials, but they have not yet been field tested in cold water conditions.[13] The capacity of foams to absorb oil was found to be largely independent of the viscosity of the oils, and they have shown high absorption rates for heavy crude oils and Bunker C oils.

The evaporation of volatile constituents in oil inhibits its absorption by absorbents but, during the wintertime, evaporation is decreased and additional time could be available so that absorbents could be deployed more effectively.

Absorbents cannot be used in conjunction with detergents or dispersants since these agents permit water to set and spread on the absorbent, competing with the oil and lowering the absorbent's capacity.[14]

Perhaps even more important than the capacity of an absorbent is its ease of dispersal and collection; so important in fact, that Coast Guard experimenters in the Artic favored straw over peat moss on these grounds, even though peat moss proved far more effective an absorbent per unit of weight.[15]

Absorbing agents, as well as herding agents, skimming by vacuum, skimming by pumping or burning could also be used in recovery of oil in a flowing river once the ice and oil have been separated. This separation could be performed with the use of a perforated boom. This boom would allow the passage of oil through it to be collected by a non-perforated second boom.

[13] Schatzbert, P., and Nagy, J.V., "Sorbents for Oil Spill Removal", American Petroleum Institute

[14] Schatzbert and Nagy, op.cit.

[15] Glaeser and Vance, op.cit.

This method of separation of ice and oil is the result of a theoretical investigation conducted under Operation Preparedness, Oil Spill on the St. Clair and Detroit Rivers.[16] The report states "that the task of containing and controlling spilled oil on the St. Clair and Detroit Rivers under ice conditions is not as formidable as thought at first. With more work and effort, an action plan to contain and recover oil does seem attainable." The report further concludes that the probability of an oil spill in ice is higher for the spring breakup period than for winter freeze-up period.

Treatment Methods Not Involving Recovery. Biodegradation of oil consists of allowing living organisms, primarily bacteria, to break the oil into compounds that may be used by higher organisms. Biodegradation of oil globules takes place very slowly in cold temperatures, and Coast Guard experiments have shown that in the arctic, at least, no bacteria were available which would degrade hydrocarbons at water temperatures near 32°F.[17]

Burning, _in situ_, represents another method of oil disposal that has been attempted frequently. Oil spills have been burned in cold water with anywhere from good to limited success. One problem is that the rapid transfer of heat to cold water decreased the oil temperature below the flash point. Another is that the lowered viscosity of the burning oil allows it to spread into films that are not thick enough to promote burning. Perhaps the biggest objection to burning is that it merely exchanges air pollution for water pollution.

If no other tactic is available, burning may prove quite effective if induced before the oil has a chance to disperse. In Coast Guard Arctic experiments, crude oil (both fresh and six-day oil) was easily burned in frigid water, especially when confined by an ice boom and wicked with straw or other absorbents.

[16]Tsang, Gee, 1975, "Ice Conditions and Proposed Containment and Removal of Spilled Oil on St. Clair and Detroit Rivers". A report for Operation Preparedness, Oil Spill on St. Clair and Detroit Rivers. Scientific Series No. 56, Inland Waters Directorate, Canada Centre for Inland Waters, Burlingto, Ontario

[17]Ramseire, R.O., "Oil Pollution in Ice-Infested Waters", an article in Proceedings of Environmental Pollutants Conference, Ottawa, 1 June 1971

Dispersants represent the opposite approach from containment and collection. If it is decided to use dispersants they must be employed early because they rapidly become ineffective due to the emulsification process. In the few cases where chemical dispersants have been used in arctic and subarctic spills their performance has been quite disappointing, apart from adverse ecological considerations.[18] In the presence of slush or solid ice at low temperatures, oil viscosity increases to the point where dispersants have little or no effect. It is also nearly impossible to supply sufficient mixing energy.

Oil Spills on Ice. There have been few sizeable oil spills on ice, but some conclusions could be drawn about the behavior of oil on ice from known incidents and recent Coast Guard experiments.

It is known, for example, that ice absorbs oil and lowers its evaporation rate, retarding the aging process. Oil absorbed by a porous ice surface evaporates at a rate approximately 25 percent of that oil on a free surface. The oil, in turn, decreases the light reflectance of the ice and increases its rate of melting.[19]

The spreading rate of oil over ice is greatly affected by the character of the ice, the presence of meltwater, and wind. The velocity of wind-driven oil over the surface of sea ice is reported to be one-third of that over water, i.e., 1.1 percent of the wind velocity.[20]

Where ice is extremely porous, as in summer arctic ice, burning could be a highly effective method of removing oil, and when the ice is comparatively nonporous, the fuel oil cover will burn even better. In a Coast Guard winter experiment, oil uncovered from beneath 14 inches of snow following 14 weeks of aging was only 70 percent removed after ignition by fuel soaked rags, whereas more than 90 percent was burned off in an experimental fresh oil spill. The Coast Guard experiments showed that oil

[18]Ramseire, op.cit.

[19]Ibid

[20]Ibid

several days old will burn furiously on ice, but oil that has been covered by snow is extremely difficult to ignite. The reason for this is that as snow covers an oil pool at the ambient air temperature, the oil migrates upward to the snow surface, forming a mulch that is as much as 80 percent snow. In conditions of extreme cold, absorption of oil into the snow or ice surface is minimal. This is because the spilled oil is warmer than the ice/snow surface, causing a melting and refreezing of the snow/ice surface that blocks pore channels.[21]

As pointed out earlier, the chemical aging of oil in cold conditions is minimal so burning may be deferred as a tactic for removing the oil if snow is not imminent. This was demonstrated in a Coast Guard winter experiment where the viscosity of crude oil tested at 60°F after aging on ice did not change significantly over 15 days.

Herding and burning agents have both proven ineffective in oil spills on ice, and absorbents were judged by the Coast Guard to be of little or no practical use in extremely cold conditions.[22]

If the spill occurs on strong enough ice, it may be possible to utilize bulldozers or other scraping devices to remove the oil from the ice, providing a great deal of absorption has not taken place (and such absorption is unlikely in very cold conditions). Oil on ice, while uncovered, remains a discrete layer that is readily scraped off. If the ice is not strong enough to withstand heavy equipment, shoveling gangs may accumulate the oil for removal in barrels.

In summary, an immediate response to an oil spill on relatively thick ice, with or without a snow layer that may be used as a working platform, is not necessary. As long as the spreading of the oil is accurately monitored (not always easy with snow-cover), the time may be taken to plan a coordinated response based on the location of the spill and the specific situation.

[21] McMinn, T.J., "Crude Oil Behavior on Arctic Winter Ice", a final report of Coast Guard Project No. 734108

[22] Ibid

Oil Spills Under Ice. In the event that a tanker vessel should be ruptured in one or more tanks beneath the waterline in the presence of an ice-cover, the oil strike force would be faced with cleaning up oil that is not immediately accessible. Little is known about the behavior of oil beneath ice; and, it is felt that this kind of spill would be the most difficult to deal with due to the lack of tested recovery methods.

Research has shown that oil released beneath an ice-cover tends to congregate in pockets which remain quite stable in the absence of current due to capillary action.[23] Actual field experiments conducted by the Coast Guard in arctic ice indicate that oil pockets are susceptible to the dispersing effects of currents. Even where the ice is smooth, however, there is a greater coupling effect between oil and ice than between oil and water. At least two strategies have been proposed for dealing with these oil pockets. The first is to pump the oil out of the pockets into the ice platform in order to speed evaporation of the volatile constituents with the greater surface area exposure.[24] The second is to use compressed air pumps to drive the oil out of pockets to an open water collection point in the direction of current or stream flow.

Boom containment methods have been suggested for handling oil spills under thin ice (less than four inches thick). Betts and Fuller recommended smashing a channel in the ice to install floating booms. For thicker ice they suggest deploying inflatable booms or flexible circular flotation chambers beneath the ice and cutting upstream holes in which to recover the oil by skimmers.[25] Such a method of containment presupposes that the underside of the ice is smooth.

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[23]Glaeser and Vance, op. cit.

[24]Barber, F.G., "Oil Spilled with Ice", American Petroleum Institute, op. cit.

[25]Betts, W.E.; and Fuller, H.I., "An Integrated Program for Oil Spill Cleanup", American Petroleum Institute, op. cit.

In some circumstances, the oil might be totally entrapped by the ice itself. It has been shown that ice does not grow through oil, but instead pockets it neatly as more ice grows under it.[26] This so-called "sandwiching" effect would confront removal crews with the necessity of removing both oil and ice. In January 1972, a spill of 1,000 gallons of No. 5 and No. 6 fuel oil occurred onto the 6-inch thick ice-cover of the Saginaw River near Saginaw, Michigan, allowing this effect to be observed on a small scale. The hot oil melted 2 to 3 inches of ice, and cooled into a 20 by 50 foot mass on and in the ice. After six days of aging, the oil was quite hard and was recovered by breaking the ice with a crane, removing it, and separating the melt-water and oil. Up to this point, no improvements have been made on this method. This type of problem in an offshore situation would probably require an icebreaker to smash the ice and a crane-equipped barge to load the chunks of ice for separation either on the spot or at a docking facility, depending on the magnitude of the spill. The potential cost of such an operation is enormous and should be balanced against more conventional means of dealing with the spill after the ice melts.

Biological Effects of Oil Pollution.

Severe biological and ecological degradation could be caused by a major oil spill. The divergence of opinion on the nature and magnitude of the biological effects due to oil pollution exists primarily because data is either incomplete, superficial or both. Second, oil is a variable mixture of many chemical compounds.

Although this variable mixture may contain similar compounds with common properties, the properties of compounds may differ greatly in other mixtures. In either case, if released into the environment adverse effects could occur. The properties include toxicity, solubility, biodegradability, volatility, density, surface activity and carcinogenicity.

[26]Wolfe, S.L.; and Hoult, D.P., "Effects of Oil under Ice, a study conducted for the U.S. Coast Guard by the Massachusettts Institute of Tech., August 1972

The general effects of oil pollution on an aquatic environment could vary by impact and degree. These include:

a. Direct kill of organisms through coating and asphyxiation.

b. Direct kill through contact poisoning of organisms.

c. Direct kill through exposure to water-soluble toxic components of oil at some distance in space and time from the accident.

d. Destruction of the generally more sensitive species.

e. Destruction of the generally more sensitive juvenile forms of organisms.

f. Incorporation of sublethal amounts of oil and oil products into organisms resulting in reduced resistance to infection and other stresses (the principle cause of death in birds surviving the immediate exposure to oil).

g. Destruction of food values through the incorporation of oil and oil products into fisheries resources; and

h. Incorporation of carcinogens into aquatic food chain and human food resources.

Oil and greases could have a devastating effect upon waterfowl as well as upon life within the water; the problems for waterfowl are compounded by low water temperatures. Therefore, waterfowl appear to be the most vulnerable of the living resources to the effects of an oil spillage.

Waterfowl have insulating air pockets within their plumage; these are destroyed by oil, a relatively small spot being sufficient in winter to allow numbing exposure to cold water. A bird so exposed is unable to maintain its body temperature, easily becomes debilitated, and eventually may starve. The 1970 Pollution Report of the International Joint Commission presents several case histories of this sequence of events. Other sources report that on the Detroit River alone, 10,000 to 12,000 ducks perished in March-April 1960 and 5,000 in March 1967--these deaths being generally attributed to oil accumulations on the birds (Nelson, 1967). Hunt (1961) cites cases of oily birds whose unusually vigorous preening had removed much of their plumage; he also reports having found certain toxic effects related to ingestion of oil; in addition, he indicates that oil in some way reduces the impermeability of the bird's plumage to water, resulting in lower survival possibilities.

It might be noted in passing that, apart from its effects on waterfowl, oil can have severe effects upon life forms within the water. As oils are broken down, they exert a sometimes heavy oxygen demand. Also, emulsified oil, sinking to the sediments, can form a sterilizing blanket, wiping out many bottom-dwelling organisms. An oil slick which remains on the surface, prior to biological degradation, also has detrimental effects on aquatic fauna, restricting passage of oxygen across the air-water interface.

Oil Spill Response Mechanism in the Great Lakes.

The oil spill response mechanism in the Great Lakes is designed to discover spills through surveillance, provide for timely notification of all those charged with responsibilities (or who can otherwise assist), evaluate the situation, initiate immediate containment and counter measures and provide for cleanup, mitigation and disposal, should the discharger be unknown or be inadequate to the task. Funds are provided through the

National Pollution Revolving Fund established by the Federal Water Pollution Control Act of 1972, Section 311. Existing operative plans are the National Contingency Plan, the Great Lakes Region Contingency Plan, Sub-regional Contingency Plans and a Joint U.S.-Canada Contingency Plan (utilized when both Canadian and U.S. waters are affected or threatened).

As provided in the National, International and Regional Plans, the Coast Guard is charged with providing the Federal Pre-designated On-Scene Coordinator (OSC) in the coastal regions of the Great Lakes while the USEPA has that responsibility in the inland regions. The OSC is that individual having complete responsibility for on scene actions to prevent, contain, assure cleanup of, or otherwise mitigate, spills of oil. Contingency Plans contain the exact boundaries of each OSC and there is absolutely no question about who has the Federal responsibility in matters of oil spill response. The OSC's who are spread throughout the Great Lakes (there are nine in the coastal region alone) maintain sub-regional contingency plans, libraries of publications for reference and a group of well trained personnel to respond to spills or threats of spills. Each OSC is a senior grade Coast Guard Officer well trained in pollution response. Sub-regional plans contain (as a minimum) inventories of critical water use areas, drinking water intakes, potential pollution sources, known environmentally sensitive areas, scientific communities, local contact points, and cleanup contractors and equipment.

The National Plan also mandates the existence of Regional Response Teams (RRT) to advise and assist the OSC. Usually functioning at or near the site of the discharge, the Team performs organizational functions such as determining if a shift of OSC's is appropriat   ring availability of resources, identifying and arranging for expertise at the Regional, National, even International level. The team is chaired by the USCG or USEPA, depending on the location of the discharge (coastal or inland region). Other primary members are the Army Corps of Engineers, Department

of Commerce (Marad and National Weather Service) and Department of Interior (Fish and Wildlife Service and Coast and Geodetic Survey). Advisory Agencies are the Departments of Justice, State, HEW and HUD. State membership is welcomed and has been very effective. Expertise in the Great Lakes has shown that, despite the remoteness of some spill locations, the Regional Response Team, having received timely notification, has proceeded to the site in sufficient time to perform very effectively. However, public input to this study has shown a desire to reduce the response time even further by having more equipment available where spills are most probable to occur or where they could do the most damage.

The National Response Team (NRT), chaired by the USCG and USEPA and with membership similar to the RRT, performs similar roles but at the National level. This team normally functions at the National Response Center in USCG Headquarters, Washington, D.C. National and international contingency planning and provision of large scale resources are but two of the important roles of the NRT.

One of the most important ingredients to oil spill response is the National Strike Force. Consisting of three Strike Teams (Atlantic, Pacific and Gulf) the Force is composed of highly skilled Coast Guardsmen wholly dedicated to oil spill response. The Teams either have at their home bases, or know where to obtain, the most sophisticated containment, transfer and cleanup equipment available, and fast prop jet cargo aircraft (C-130's) to deliver it. Four hour response time from initial notification to arrival at the nearest suitable airport in the Great Lakes would be the norm, rather than the exception. Especially trained in all elements of oil spill response, including diving and salvage, the Strike Teams provide meaningful and timely assistance to the On-Scene Coordinator.

The mechanism described above is not theoretical but has been put to the test in several major spills or potential spills. The HANNAH BARGE 2901 (Milwaukee Harbor, 24 Feb. 1975), the EDMUND FITZGERALD (Whitefish Bay, 11 Nov. 1975), the GAELIC BARGE E-17 (Cleveland Harbor, 19 May 1976), the NEPCO 140 (St. Lawrence River, 23 June 1976) and AMOCO INDIANA (Grand Traverse Bay, 11 Jan. 1977) are but five such instances.

Conclusions: Oil and hazardous material spills occurring in an ice environment could pose special problems. These problems include adequate cleanup equipment, personnel, and logistic limitations inherent in the season and expanse of territorial occurrence. Yet, within 4 hours from initial notification, specially trained teams and the most sophisticated containment, transfer and cleanup equipment could be available at the nearest suitable airport in the Great Lakes. A river system, though, may pose additional problems due to the water regime and potential for rapid dispersion of the pollution. Although significant research and development of cold regions oil recovery is presently being conducted, an additional response mechanism is recommended.

A recommended alternative response mechanism, that could be used in conjunction with the oil spill response mechanism presently in use, would involve the stockpiling of oil and hazardous material cleanup equipment along critical areas involved with navigation in an ice environment. This storage of equipment could provide a savings in time needed to respond quickly to a rapidly dispersing pollutant. At a minimum, this equipment, when deployed, could deflect the substance from affecting environmentally sensitive areas along river systems, while additional containment and recovery equipment are being transported to the scene. Detailed plans would be developed through the EPOA.

SECTION F-V

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